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#### CORRECTIONS

REVIEW, October, 1927:

The legends to the half-tone illustrations facing pages 448 and 449 should be interchanged.

REVIEW, November, 1927:

On page 492, second column, the entire column beginning with "The race this year, etc.," belongs on the opposite page (493) and forms the opening of the article on that page.

# MONTHLY WEATHER REVIEW

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## WINDS AND STORMS ON THE ISTHMUS OF PANAMA

By L. T. CHAPEL, Meteorologist in Charge Hydrographic Office

[Cristobal, Canal Zone, July 14, 1927]

### GEOGRAPHICAL POSITION

*Introduction.*—The geographical position of the Isthmus of Panama is such as to give it practically every variety of wind and storm that occurs within the Tropics. Its location near the thermal equator, and also near the north-south line of displacement between the great wind belts of the Atlantic and the Pacific, bring it successively under the migratory influence of the northeast trades of the Atlantic, the equatorial calm belt, and the southeast trades of the Pacific, or at least, a northward extension of those winds. The general breakdown in the high pressure belt of the horse latitudes to the northward of the Central American Isthmus during the northern summer and autumn makes possible extensive interchange of storms between the two zones, providing an easy avenue of invasion northward by the cyclones of the Tropics, and, later in the year, a return invasion by the cold waves and northers of the Temperate Zone.

The greatest influence on the weather of the Isthmus is exercised by the northeast trades. They usually blow with great steadiness from January to April, inclusive, with occasional extensions into December and May. The duration and general characteristics of the dry season depend upon them.

In June, September, and October of the rainy season, but especially in September and October, a large southerly component is evident in the wind movement over the Isthmus. Sometimes for periods of several days southerly winds will blow with the constancy of, and only slightly less velocity than, the northeast trades. Occasionally they are of sufficient strength and duration to cause heavy seas in Panama Bay.

The migration of the belt of doldrums northward with the sun and its return equatorward brings it over the Isthmus from June to November, inclusive. The trades usually weaken early in May and rainy season conditions become well established before the close of the month.

The trades sometimes resume as early as the first week in December, but usually not until later.

Tropical cyclones do not extend as far south as the Isthmus of Panama, but their appearance in the western Caribbean is frequently attended by pronounced changes in wind and other elements. Heavy rains of a general nature occur near the beginning and also near the end of the rainy season, but the winds accompanying them are usually light. Occasionally a norther occurs this far south.

While many influences are in evidence in the winds at the Isthmus of Panama, the winds themselves and what storms occur are comparatively light. No excessive wind velocities have ever been recorded. The highest for a five-minute period in a 19-year record at Colon is

46 miles from the north. The highest ever recorded on the Isthmus is 59 miles from the south at Balboa Heights. Damage by storms is mostly of a secondary nature, by heavy seas on open coasts and unprotected harbors, or by floods due to excessive and long-continued rains.

### WIND RECORDS

*Available instrumental records.*—Standard United States Weather Bureau equipment, including Robinson cup anemometers, anemoscopes, and automatic registration of simultaneous values of wind direction and velocity, has been in use on the Panama Canal since 1908.<sup>1</sup> Stations have been located at various places along the line of the canal, from Colon, on the Caribbean coast, to Balboa, at the head of Panama Bay. The Colon record is the only one extending over the entire 19-year period, 1908-1926, inclusive, under essentially similar conditions; changes having been made in the location of all the other stations.

During 1919-1922, inclusive, standard Weather Bureau equipment was in use at Cape Mala, at the entrance to Panama Bay and 113 nautical miles almost due south from Colon. Simultaneous values of wind direction and velocity are available for approximately a three-year period.

In addition to the stations maintained by the Panama Canal, meteorological records have been kept in recent years at the Army and Navy aviation fields adjacent to the canal terminals. At the naval air station at Coco Solo, 1¼ miles east-northeast from the Colon weather station, records of pilot balloon flights from 1922 to the present time are available.

*Exposure of instruments.*—Colon is located on the Caribbean coast, on a coral island, in no place over 10 feet above the level of the sea, and is surrounded by water and mangrove swamps for a distance of about 2 miles. The trend of the coast is northeast-southwest for about 20 miles on each side, giving an open sea exposure from southwest through west and northwest to northeast. On the land side, Gatun Lake lies to the south at a distance of about 7 miles, with an elevation of 85 feet above sea level. To the southeast and east isolated hills reach an elevation of 800 feet at a distance of 7 miles and 2,000 to 3,000 feet at a distance of from 15 to 20 miles. There is no definite valley formation opening on this section of the coast which could effect local winds. Since February, 1917, the exposure of the wind instruments at Colon has been on a skeleton steel tower 97 feet above the ground and about 105 feet above the level of the sea. The location since 1908 has never

<sup>1</sup> A fully equipped first-order station of the United States Weather Bureau was in operation at Colon from September, 1893, to May, 1899.—Ed.

(Note.—All temperatures are in Fahrenheit degrees; wind velocities expressed in miles per hour.)

been less than 70 feet above the ground, well overtopping all near-by buildings and trees, and never farther than 200 feet from the beach.

The elevation of exposure of all of the interior stations along the canal is comparatively low, and the instruments of necessity are overtopped by neighboring hills and trees; hence wind conditions are greatly influenced by the trend of the valleys.

The exposure at Balboa Heights is the best obtainable, but it is located in a valley opening on the head of Panama Bay, with ranges of hills on either side rising to an elevation of 1,500 feet or more. About one-fourth mile to the eastward of the station and subtending an angle of about 90° is an isolated hill rising over 300 feet above the anemometer exposure. Short records kept on Sosa Hill, about 1 mile to the southwest of Balboa Heights and near the middle of the valley, show 90 per cent of the dry-season wind and 70 per cent of the rainy-season wind from the northwest and most of the remainder from the southeast. The influence of drainage up and down the valley in the direction of Panama Bay is thus clearly indicated.

All of the stations along the canal, with the exception of Colon, are subject to marked influences by local topography. Colon seems comparatively free of any such influences, but, on those comparatively rare occasions when a general air movement northward across the Isthmus occurs, a tendency is noted for southwest winds in the Gulf of Panama to become southeast winds at Colon. Similar influences are apparent at no other time. This peculiarity is perhaps due to a general surface drainage northward across the Isthmus from the head of Panama Bay over the lowest point in the divide toward the Caribbean.

The Cape Mala instruments were located on top of the lighthouse, a skeleton steel tower, 100 feet high and about 140 feet above the level of the sea, also well above every neighboring object. The station is open to sea exposure from north through east to southwest. The land is low and comparatively level for several miles inland. At a distance of about 6 miles low hills attain an elevation of 300 feet, and about 20 miles west-northwest of the station near the center of the peninsula a maximum elevation of about 3,000 feet is attained over a small area. There are no valley formations that could affect local winds.

At the naval air station at Coco Solo most pilot-balloon flights have been made for practical purposes only and to comparatively low levels. Prior to August, 1924, their standard flight was to 2,000 meters; after that date it was increased to 3,000 meters, cloud conditions permitting, with an occasional flight to higher levels. These records furnish averages that are probably a good index to the general air movements up to the three or four thousand meter level.

#### AIR AND WATER TEMPERATURES

The records at Colon and Cape Mala would seem to be nearly free from local influences, with the exception of the land and sea breeze. These winds at Colon would have a tendency to blow toward and from the hill area to the eastward of the station, while at Cape Mala the direction would be toward and from the hill area to west-northwest of the station. As these winds are due to temperature contrasts, between the land and water surfaces, and as the temperature of the Caribbean all of the year, and of the Pacific most of the year, does not vary much from the mean air temperature over the land,

the land and sea breezes are comparatively light. In fact, they seldom appear as such, but are evident only as a diurnal variation in the general winds.

Average air temperatures at Colon and Cape Mala and average water temperatures of the Caribbean and of the Pacific are as follows. The water temperatures are from the averages of bihourly values of water thermographs in Colon and Balboa harbors, and immediately adjacent to water about 40 feet in depth.

#### AIR TEMPERATURES AT COLON—AVERAGE OF 19 YEARS' RECORD

Mean daily	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Maximum.....	84.0	84.0	84.7	85.3	85.8	85.2	84.8	84.8	85.7	85.4	83.9	84.2	84.8
Minimum.....	76.3	76.2	76.8	77.0	76.2	75.5	75.9	75.6	75.0	74.5	74.6	75.8	75.8
Range.....	7.7	7.8	7.9	8.3	9.6	9.7	8.9	9.2	10.7	10.9	9.3	8.4	9.0

#### AIR TEMPERATURES AT CAPE MALA—AVERAGE OF 38 MONTHS' RECORD

Maximum.....	84.9	84.5	85.9	85.8	86.3	84.9	84.2	84.2	83.7	83.3	84.5	85.0	84.8
Minimum.....	74.6	73.7	73.7	75.4	75.4	74.1	74.0	74.0	73.2	73.0	73.6	74.2	74.1
Range.....	10.3	10.8	12.2	10.4	10.9	10.8	10.2	10.2	10.5	10.3	10.9	10.9	10.7

#### WATER TEMPERATURES—COLON AND BALBOA—AVERAGE OF 19 YEARS' RECORD

Colon.....	80.3	80.2	80.8	82.1	82.7	83.4	83.0	82.9	83.3	83.0	81.9	81.2	82.1
Balboa.....	78.6	74.5	73.1	76.2	81.6	82.9	82.4	82.8	82.8	82.2	81.4	81.0	80.0

The range of air temperature would probably be several degrees greater at interior stations, although the high humidity and limited extent of land area prevents any great variation. The greatest departure in water temperature is in the Pacific in February and March, at the time of the greatest northward extension of the cold Peruvian current. The temperatures given are for Balboa, at the head of Panama Bay, and nearly 100 miles from Cape Mala. Ship reports frequently show temperatures 5° lower near the entrance of the bay. At Cape Mala in the month of March during the hottest part of the day temperature contrasts between land and water surfaces of 20° or more frequently occur. At Colon the maximum temperature differences would probably be less than half this amount.

#### LOCAL WIND RECORDS AS AN INDEX TO GENERAL AIR MOVEMENTS

The Colon record, complete for the 19-year period, 1908-1926, inclusive, under essentially similar conditions throughout, would seem to offer the best index to general wind movement over the Isthmus. For purposes of check and comparison, the record at Cape Mala, although covering only a short period, would, on account of its location and freedom from local influences, seem to offer the best material. The available record at Cape Mala, with simultaneous values of both wind direction and velocity, covers a period of slightly under three years, during 1919-1922. The record for 33 months has been summarized, 18 months complete and 15 months with hours missing. The missing record is so distributed as to have little effect on the monthly means.

The coordinates of the two stations are: Colon, 9° 21' N., 79° 54' W.; Cape Mala, 7° 28' N., 80° 00' W.; making Cape Mala 113 nautical miles almost due south of Colon. The stations are situated on opposite sides of the Isthmus,

the relative positions of land and water areas are nearly the reverse of each other, and the distance apart is sufficient to eliminate all common local influences.

For comparison with free air data, the following observations made at the naval air station at Coco Solo over a period extending from January, 1922, to March, 1927,

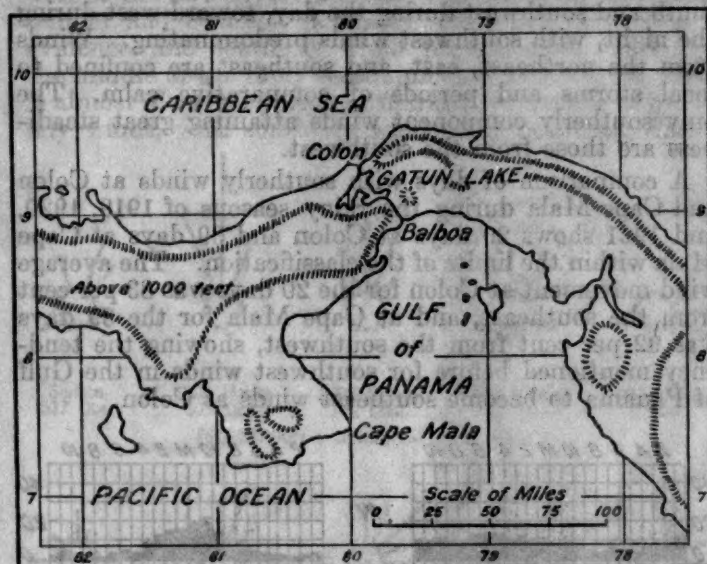


FIG. 1.—Isthmus of Panama

are available: Number of observations at 1,000-meter level, 1,109; at 2,000-meter level, 498; at 3,000-meter level, 217; and at 4,000-meter level, 60. These numbers include both morning and afternoon flights, and only selected levels are considered. The number of observations above the 1,000-meter level are too few for precise averages, but afford material for interesting comparisons with surface conditions.

An outline map of the Isthmus of Panama showing relative positions of land and water areas and of the meteorological stations mentioned is shown in Figure 1.

#### WIND DIRECTION

**Annual variation at Colon and Cape Mala.**—The annual march of wind frequencies at Colon and Cape Mala is shown in Figure 2. It will be seen that the winds during the trade-wind season are mostly from the north and northeast at Colon, while at Cape Mala they are from the northwest and north. Northerly winds of considerably decreased velocity make up a substantial proportion of the total during the rest of the year, but the prevailing directions are usually southerly or westerly, ranging from southeast to west at Colon and from southwest to northwest at Cape Mala. No general air movement from the east is in evidence at any time.

**Diurnal variation at Colon and Cape Mala.**—As mentioned previously, the land and sea breeze seems to be the only local influence at either station, and this usually appears only as a deflective force acting upon the current prevailing winds. Consideration of the diurnal variations peculiar to each station, due to this cause, is necessary in a comparison of wind directions. As will be seen from the map, the sea breeze at Colon would tend to blow toward the elevated area to the east of the station, while at Cape Mala it would tend to blow very nearly in the opposite direction, toward the west-northwest.

At Colon all winds tend to shift toward the west or northwest during the afternoon, under the influence of the sea breeze; under the influence of the land breeze, during the night and early morning, northerly component

winds will tend to shift through north toward northeast and east, while southerly winds will back through southwest and south toward southeast.

At Cape Mala nearly the reverse is true, all winds tending to shift toward west and northwest during the night and early morning under the influence of the land breeze; northerly component winds shifting to north and southerly component winds backing to southwest and south during the afternoon under the influence of the sea breeze. The range of variation depends upon the force of the winds, the high winds holding steady with but little change.

It will be seen that the direction of the land-sea breeze line at both stations is very nearly ESE.-WNW., one station being the reverse of the other, and that the northerly and southerly component winds at each station, considered in their relation to this line, have a distinct diurnal variation of their own. The diurnal variation during the height of the trades, from January to March, is almost wholly of the northerly component type characteristic of each station, while the diurnal variation, late in the rainy season, during September and October, is equally characteristic of the southerly component types. The winds of the other months are a transition stage between these extremes, the two types being intermingled in varying proportions in the monthly averages.

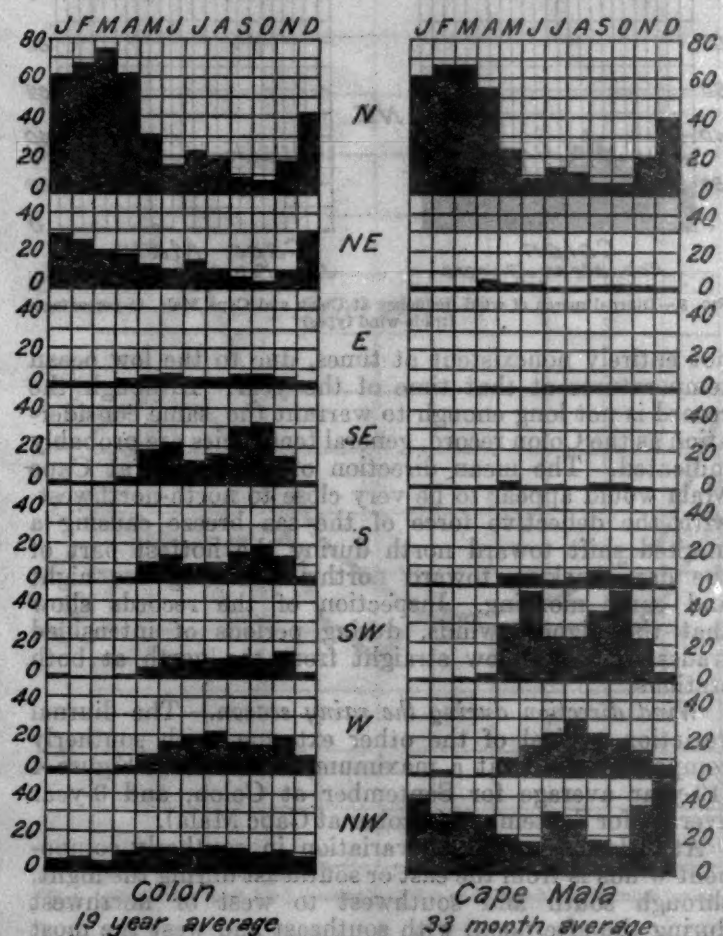


FIG. 2.—Annual march of wind frequency at Colon and Cape Mala, in percentages

**Mean direction of the trades.**—The diurnal variation typical of the trade winds is shown in Figure 3 (19-year averages for February at Colon and 3-year averages for January-February at Cape Mala).

At Colon the deflective effect of the land breeze appears in the averages as a marked increase in the frequency

of the northeast winds during the early forenoon. As the extreme shift to northwest under the influence of the sea breeze seldom occurs, it would appear that the mean direction of the trades at Colon is somewhat to the east of north.

At Cape Mala, from January to March, inclusive, the force of the land breeze is probably very light, if

blow for a few hours at a time, but usually shift to other directions before the day is over. But at times of general air movement from the Pacific across the Isthmus toward the Caribbean the wind may blow steadily from the southeast for several days at a time.

At Cape Mala southerly component winds range from south and southwest during the day, toward west during the night, with southwest winds predominating. Winds from the northeast, east, and southeast are confined to local storms and periods of comparative calm. The only southerly component winds attaining great steadiness are those from the southwest.

A comparison of days with southerly winds at Colon and Cape Mala during the rainy seasons of 1919, 1920, and 1921 shows 20 days at Colon and 39 days at Cape Mala within the limits of the classification. The average wind movement at Colon for the 20 days was 83 per cent from the southeast, and at Cape Mala for the 39 days was 92 per cent from the southwest, showing the tendency mentioned before for southwest winds in the Gulf of Panama to become southeast winds at Colon.

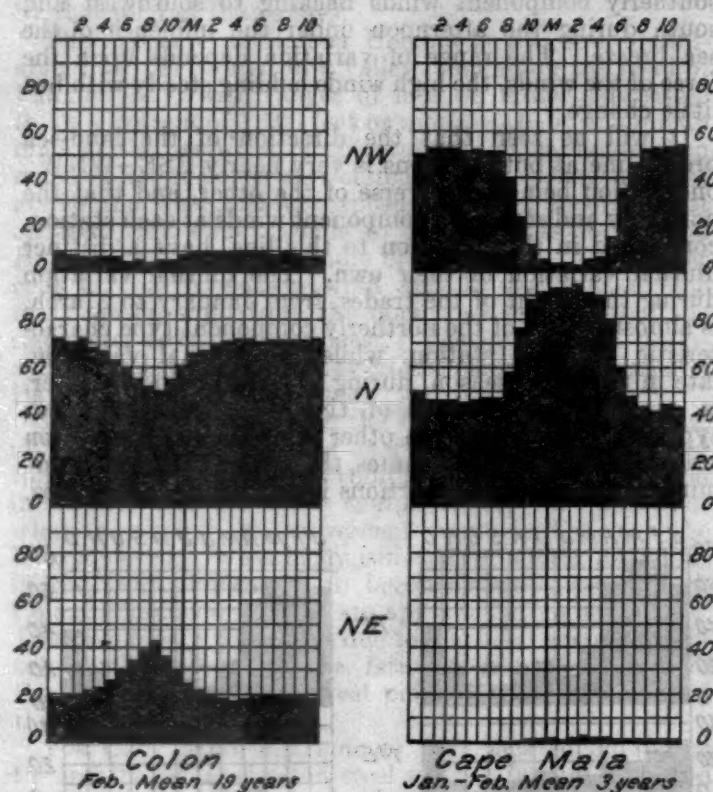


FIG. 3.—Diurnal march of wind frequency at Colon and Cape Mala, in percentages (trade-wind types)

not entirely nonexistent at times, due to the low ocean temperatures at that time of the year. Although the record is not long enough to warrant the same consideration as the Colon record, general tendencies are probably indicated. The mean direction of the trades at Cape Mala would appear to be very close to north-northwest, with the deflective force of the sea breeze causing a marked shift toward north during the hottest part of the day, backing toward northwest during the night and early morning. Inspection of the records show that the highest winds, during periods of intensified trades, tend to blow straight from the north at both stations.

*Wind direction during the rainy season.*—The diurnal variation typical of the other extreme, with southerly component winds at a maximum, is shown in Figure 4 (19-year average for September at Colon, and 3-year average for September–October at Cape Mala).

At Colon the extreme variation in southerly component winds is from the east or southeast during the night, through south and southwest to west or northwest during the afternoon, with southeast and west the most frequent. Every possible gradation occurs, but there are two main types—one in which westerly winds predominate, with a shift to southerly points for only a few hours in the early morning, and one in which southerly winds predominate, with a shift to westerly for only a few hours in the afternoon. The only southerly component winds that attain any great force or steadiness are from the southeast. High westerly winds may

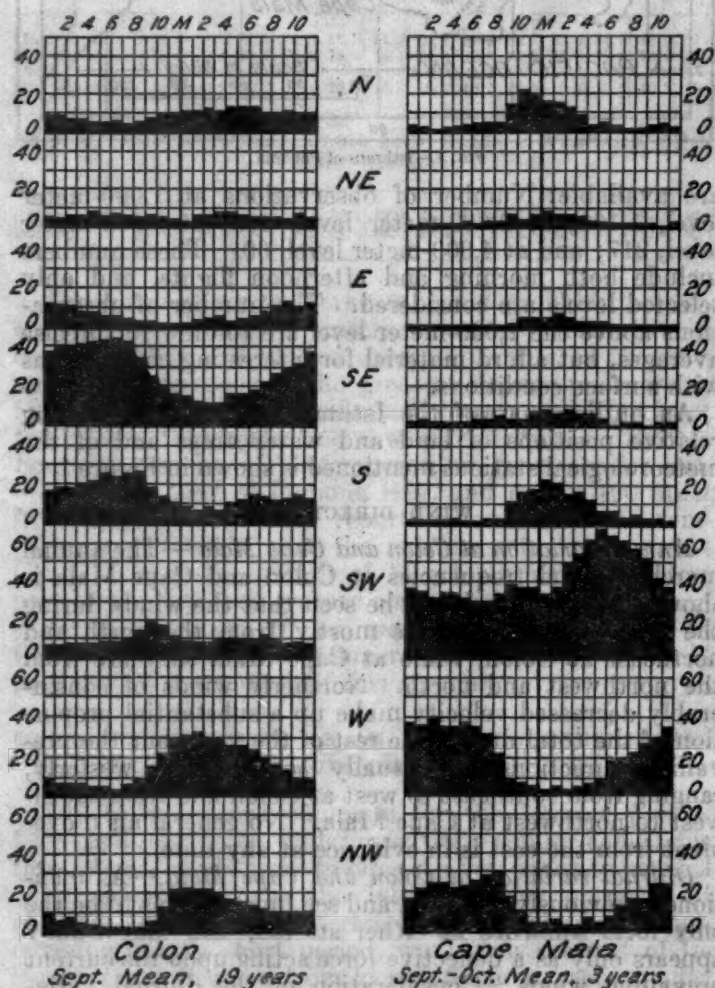


FIG. 4.—Diurnal march of wind frequency at Colon and Cape Mala, in percentages (rainy-season type)

While westerly winds at Colon are usually subject to the diurnal effect characteristic of southerly component winds, they may at Cape Mala vary either to the north or the south under the influence of the sea breeze. At Colon, in a rough classification, westerly winds can be segregated from northerly and southerly, but at Cape Mala this can not be done, as the westerly winds are too closely intermingled with the other two direction groups.

Near the beginning of the rainy season the trades begin to weaken, the range in diurnal variation increases, and southerly component winds appear, the two being intermingled in the averages. Early May and late November frequently represent about an equal distribution of the two types. During June, and again in September and October, northerly winds are very little in evidence, and southerly winds predominate. But near the middle of the rainy season, in July and August, there is almost always a period of marked recurrence of northerly winds, with southerly winds only occurring during

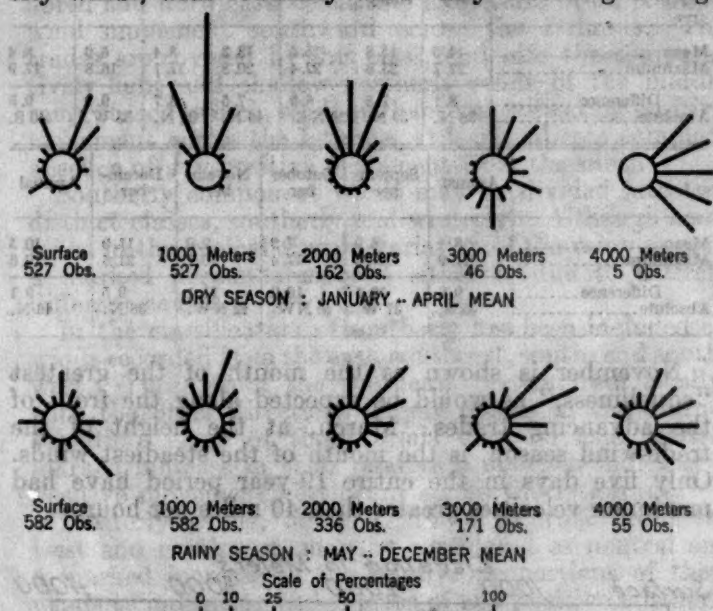


FIG. 5.—Wind frequency at selected levels for dry and rainy seasons, in percentages (Coco Solo)

local storms, or for a few hours as a part of the diurnal variation.

**Free air wind directions.**—Wind frequencies at selected levels in the free air are shown in Figure 5 (averages for the dry season, January to April, and for the rainy season, May to December, inclusive). All available pilot-balloon flights of 1,000 meters or more made at the naval air station, Coco Solo, up to the end of March, 1927, are included.

Wind percentages at the surface and 1,000-meter level are directly comparable. In the dry season averages, the surface winds are mostly from the north-northwest to northeast, with an average direction of  $N. 7^{\circ} E.$  At the 1,000-meter level the range in variation is not so great and the average direction is  $N. 4^{\circ} W.$  This would seem to indicate that the mean direction of the trades over Colon, unaffected by surface influences, is very nearly due north, with a small westerly departure from the surface mean. Beginning near the 2,000-meter level, the dry season winds become more and more variable, with a general shift toward the east.

In the rainy season averages the surface means show a marked preponderance of southeast, west, and north winds. At the 1,000-meter level this distribution disappears and the winds are well distributed among all the directions, with a marked concentration toward north-northeast. With increase in altitude, the winds continue variable, but with the average direction more and more easterly. At the 4,000-meter level it would seem that the difference between the seasons had practically disappeared. The winds are more or less variable in direction, but average very nearly due east throughout the year.

On days with intensified trades the wind direction holds steadily between north and north-northeast up to the 1,500-meter level. Observations at higher levels are not available. On days with constant southerly winds at the surface the wind direction varies from southeast at the surface through south to south-southwest at an elevation of 2,500 meters.<sup>2</sup>

#### WIND VELOCITIES

**Annual variation at Colon and Cape Mala.**—The annual march of monthly mean wind velocities for Colon and Cape Mala is shown in Figure 6. The Cape Mala winds follow a regular curve, with a maximum monthly mean of 21 miles per hour in February, a minimum of 8.2 in July, and an annual mean of 13.2. Velocities at Colon are generally lower, with a maximum of 15.8 in February a minimum of 6.9 in June and September, and an annual mean of 10.5. The greatest difference occurs during the trade-wind season. A departure from the regular curve occurs in the Colon record during July and August. This does not signify a general increase in velocity, but is a local effect, due to a change in the prevailing direction from off-shore to on-shore winds, as previously noted.

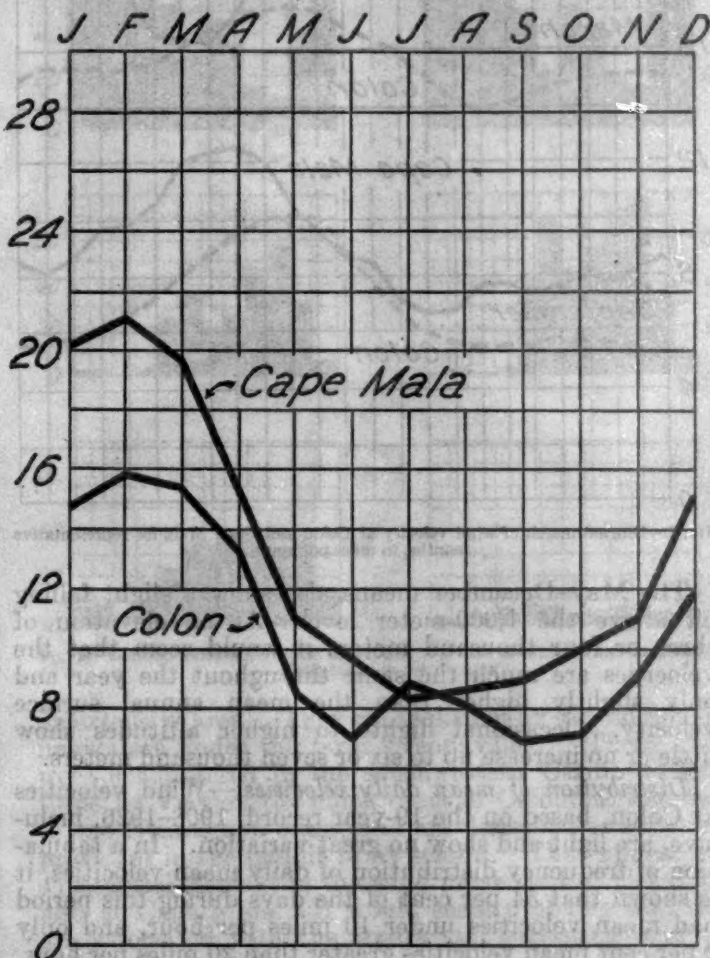


FIG. 6.—Annual march of wind velocity at Colon and Cape Mala, in miles per hour

**Diurnal variation at Colon and Cape Mala.**—The diurnal march of wind velocities for March and September is shown in Figure 7.

**Free air wind velocities.**—Comparative values of wind velocities at selected levels for the dry and rainy seasons are shown in Figure 8. The averages are based on the

<sup>2</sup>This is one more example illustrating the apparent universality of the turning of the wind with altitude in the Northern Hemisphere as found in kite and pilot-balloon flights in the United States and elsewhere.—Ed.

same number of observations as in Figure 5. The January-April means show an average of 15.4 miles per hour at the surface, increasing to 18.1 at the 1,000-meter level, and falling off to 12.8 and 11.2, respectively, at the 2,000 and 3,000 meter levels, considerably lower than the surface velocity. Inspection of the records shows that maximum velocities in the altitudes under consideration are attained at about the 750-meter level.

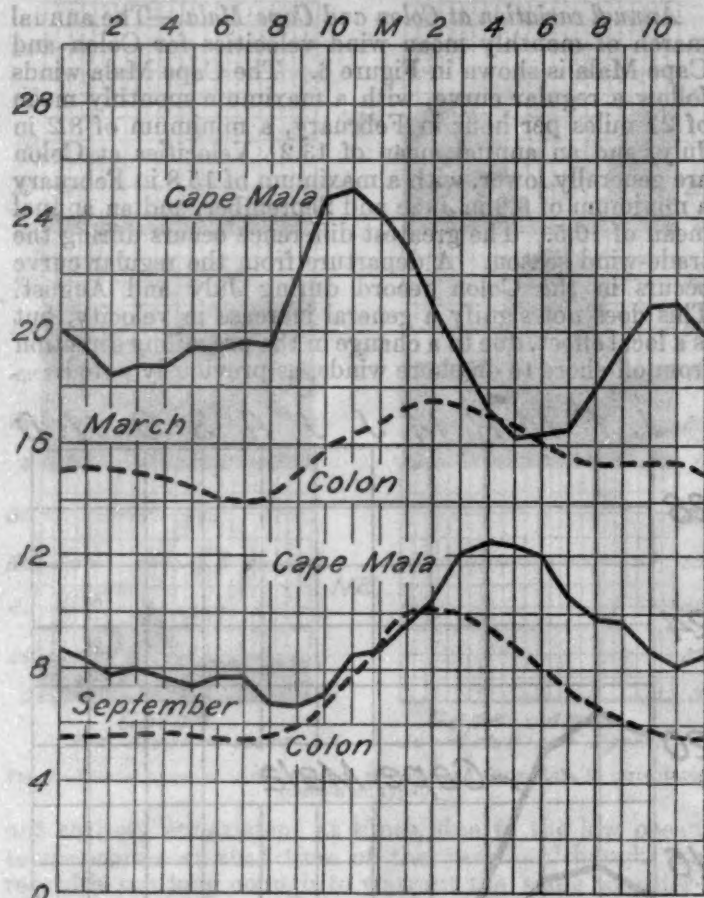


FIG. 7.—Diurnal march of wind velocity at Colon and Cape Mala for representative months, in miles per hour

The May-December means also show a slight falling off above the 1,000-meter level. At an elevation of three or four thousand meters it would seem that the velocities are much the same throughout the year and only slightly higher than the mean annual surface velocity. Occasional flights to higher altitudes show little or no increase up to six or seven thousand meters.

**Distribution of mean daily velocities.**—Wind velocities at Colon, based on the 19-year record, 1908-1926, inclusive, are light and show no great variation. In a tabulation of frequency distribution of daily mean velocities, it is shown that 54 per cent of the days during this period had mean velocities under 10 miles per hour, and only 2 per cent mean velocities greater than 20 miles per hour. Only five days during the entire period have had mean velocities in excess of 25 miles per hour, and only one day in excess of 30 miles per hour. During February, the month of greatest velocity, 83 per cent of the days have velocities between 10 and 20 miles per hour. Eight per cent have velocities under 10, and 9 per cent velocities over 20 miles per hour. During September, the month of least velocity, 76 per cent of the days have velocities between 5 and 10 miles per hour, 14 per cent under 5

miles per hour, and 10 per cent over 10 miles per hour. Only one day in the entire period had a mean velocity greater than 15 miles per hour.

Maximum velocities at Colon are also low and show little variation. A comparison of the average hourly velocities for the various months and the average of the daily maximum velocities, together with the absolute maximum, follows:

	January	February	March	April	May	June	July
Mean.....	14.6	15.8	15.5	13.3	8.4	6.9	8.4
Maximum.....	22.7	22.6	22.4	20.8	17.1	16.8	17.9
Difference.....	8.1	7.8	6.9	7.5	8.7	9.9	9.5
Absolute.....	36 N.	39 N.	36 NE.	46 N.	36 N.	33 W.	40 S.

	August	September	October	November	December	Annual
Mean.....	8.1	6.9	7.2	9.0	11.9	10.5
Maximum.....	17.9	17.0	17.4	20.1	21.4	19.6
Difference.....	9.8	10.1	10.2	11.1	9.5	9.1
Absolute.....	32 S.	37 W.	40 NW.	42 NW.	38 N.	46 N.

November is shown as the month of the greatest "squalliness," as would be expected along the front of the advancing trades. March, at the height of the trade-wind season, is the month of the steadiest winds. Only five days in the entire 19-year period have had maximum velocities greater than 40 miles per hour.

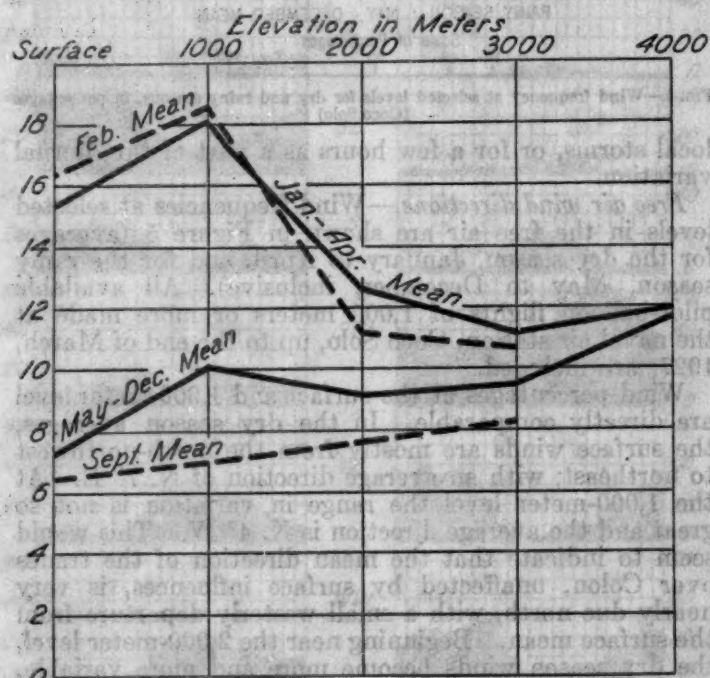


FIG. 8.—Comparative values of wind velocities at selected levels for dry and rainy seasons, Coco Solo, miles per hour

At Cape Mala both daily mean and daily maximum velocities are considerably higher than at Colon. In the three-year period under consideration there were 62 days with maximum velocities above 40 miles per hour. The absolute maximum at Cape Mala is 58 miles per hour from the northeast during a local storm. Dry-season velocities up to 56 miles per hour from the north have been recorded, marking the culmination of intensified trades.

## GENERAL WINDS AND THE DISTRIBUTION OF STORMS

*Associated wind groups.*—As suggested before, the winds at Colon may be divided into three separate direction groups with distinct causes and associations. The significant facts seem to be brought out better by a grouping of related wind directions than by resultant values. This is possible in the Colon record, as the three groups, although intermingled much of the time, are still sufficiently distinct to be segregated.

Northerly winds, including those recorded from the north and northeast, constitute a measure of all positive wind movement southward across the Isthmus. The trades are covered by this class, and also the comparatively light and shallow northerly winds of the middle rainy season, which, while perhaps not indicating positive movement across the Isthmus, at least indicate complete absence of any positive movement from the south.

Southerly component winds may be divided into two distinct classes, southerly and westerly. Although combined in the typical diurnal variation of the rainy season, a marked preponderance of either is due to entirely different causes.

In the classification of southerly has been included all winds recorded from the east, southeast, south, and southwest. Those from the southeast predominate locally, with the other directions largely phases in the diurnal variation. Any of these winds may be local, but a marked increase in their relative proportion indicates a positive movement northward across the Isthmus.

Westerly winds, including those recorded from the west and northwest, may be considered as neutral and a marked increase in the relative proportions of these winds as indicating the absence of any positive northerly or southerly movement. They are associated with light winds from all directions, but especially with the light northerly winds of the middle rainy season.

At Cape Mala it is impossible to segregate the westerly winds from the northerly and southerly on account of the lesser range in diurnal variation, but they are probably divided about equally between the other two classes, so as to not affect materially their relative proportions. Northerly winds at Cape Mala include those recorded from northwest and north, covering the trades and all similar winds. Southerly winds include those recorded from the south, southwest, and west, constituting a measure of all positive southerly movement. Southwest winds predominate. Any general air movement from easterly directions is negligible in the surface winds of both stations.

*Seasonal variation.*—The seasonal variation in wind movement classified in the above manner is shown in Figure 9.

In the Colon record the westerly or neutral winds increase with great regularity from a minimum of less than 10 per cent in January, February, and March to a maximum of 40 per cent in August. If it were possible to segregate the westerly winds, probably about the same proportion would be shown in the Cape Mala record. A marked increase in movement from the south is indicated in the records of both stations during June and again in September and October, reaching a maximum in the latter month. The southerly winds are interspersed by a marked increase in northerly wind movement during July and August. These winds, coupled with the maximum of westerly winds, both probably due to mild monsoon influences toward the South American Continent, indicate a decided absence of any positive general wind movement during that season.

*General winds.*—The only winds of the Isthmus of Panama that may be considered general in character and a part of an extensive air movement over wide areas are the northeast trades and the short intermittent periods of southerly winds most frequent in October. According to available free-air data, the influence of the trades extends upward to at least 3,000 meters, although a marked decrease in velocity and a shift toward easterly occurs shortly above the 1,000-meter level. On days with constant southerly winds at the surface available free-air data indicate that they persist to a height about equal to that attained by the northeast trades, although, with lower velocity throughout, a shift toward southwest occurs with increase in elevation. A general air movement across the Isthmus is shown, extending to a height of three or four thousand meters and perhaps higher.

Westerly winds seem to be shallow as they become variable at low levels, but at times probably cover quite

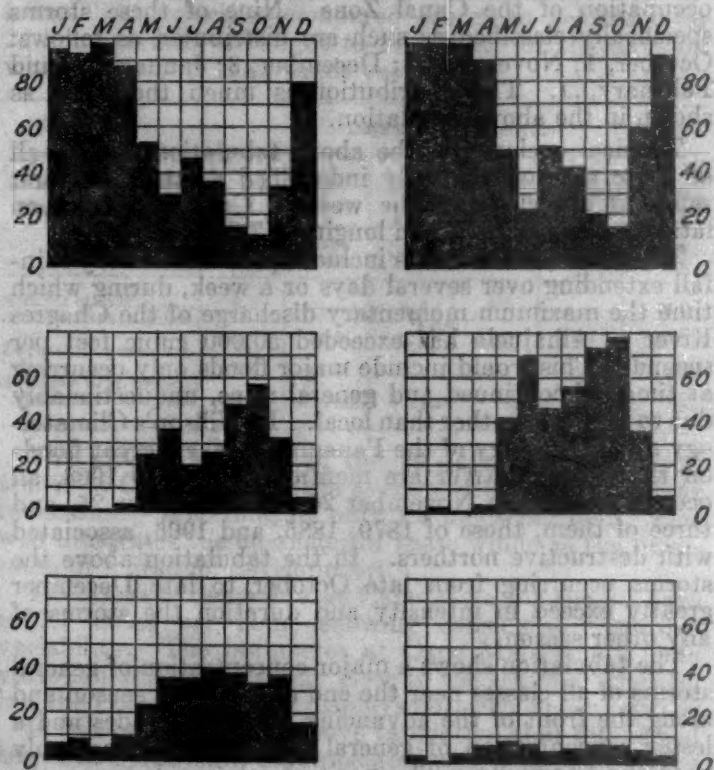


FIG. 9.—Seasonal variation in wind movement of groups of related winds at Colon and Cape Mala, in percentages

an extensive area. They are spoken of by the old Spanish navigators under the term "vendavales." These winds were encountered in the southwestern Caribbean from Cape La Vela on the north coast of Colombia westward to the Nicaraguan coast, and are described as especially prevalent in the middle rainy season. They appear as a substantial element in the wind movement at Colon and also at Cape Mala. It would seem probable that they are associated with the trades still persisting over the eastern Caribbean.

## DISTRIBUTION OF STORMS

The only storms in the Central American region covering any great area are northers, tropical cyclones, and the general and long-continued rains causing our big floods. Their distribution, by months, and a comparison with the average percentage of wind movement at Colon classified in groups of related winds follows. All values are for the 19-year period, 1908-1926, inclusive.

	January	February	March	April	May	June	July	August	September	October	November	December	Totals and means
<b>STORMS</b>	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Northerly	0	1	0	1	0	0	0	0	0	0	2	2	6
Cyclones	0	0	0	0	0	4	0	1	4	14	7	0	30
Floods	1	0	0	0	1	1	0	0	0	1	3	3	10
<b>WIND</b>	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
Northerly	93	92	96	86	53	29	46	35	16	10	33	79	64
Southerly	1	1	0	3	24	37	20	25	47	57	31	5	17
Westerly	6	7	4	11	23	34	34	40	37	33	36	16	19

The list of northerly includes only those storms occurring locally on the north coast of Panama, and that unquestionably can be classified as such. In the MONTHLY WEATHER REVIEW for November, 1917, a list of northerly is given from French records occurring prior to American occupation of the Canal Zone. Nine of these storms specifically classified as such are distributed as follows: October, 1; November, 2; December, 3; January, 2; and February, 1. The distribution is much the same as shown in the above tabulation.

Tropical cyclones in the above tabulation include all of those storms positively identified as such and first reported anywhere in the western Caribbean between latitude 10° to 20° N. and longitude 75° to 90° W.

The classification floods includes periods of heavy rainfall extending over several days or a week, during which time the maximum momentary discharge of the Chagres River at Alhajuela has exceeded 50,000 cubic feet per second. This would include major floods only occurring at times of continued and general rains, unquestionably due to influences other than local. In Willson's Climatology and Hydrology of the Panama Canal six great floods on the Chagres River are mentioned prior to 1908, all occurring between November 20 and December 25, and three of them, those of 1879, 1885, and 1906, associated with destructive northerly. In the tabulation above the storms occurring from late October to late December greatly exceed in intensity and duration the storms of any other season.

The tabulation shows a major concentration of general storms of all classes near the end of the rainy season and along the front of the advancing northeast trades and a lesser concentration of general rains and cyclones only near the beginning. The positive relation between the occurrence of cyclones and the percentage of southerly winds at Colon is obvious. During October to December, inclusive, the maximum of the hurricane season is closely followed on the Isthmus of Panama by the period of general rains, which in turn merges into the period of northerly and lesser gales, which may continue until the definite establishment of the trades late in December.

This does not take into consideration intensified trades,<sup>3</sup> which are really not storms at all, but might be considered as the maxima in a normal variation of the trades. They develop slowly and very seldom cause any damage, but sometimes constitute a considerable inconvenience, if not danger to small vessels along windward coasts.

*Diurnal variation of rainfall as an index to the character of storms.*—As another indication of the varying character of our storms, the diurnal march of the amount of rainfall

at Colon for representative months is given herewith. The values are comparative percentages and are the average of 20 years' record.

Month	Hours, midnight to midnight								Average monthly rainfall
	12-3	3-6	6-9	9-12	12-3	3-6	6-9	9-12	
March	Per cent 80	Per cent 173	Per cent 120	Per cent 62	Per cent 71	Per cent 155	Per cent 63	Per cent 61	1.34
May	115	108	111	61	122	143	78	63	12.84
August	93	121	123	69	149	101	70	69	14.86
November	120	121	121	86	91	96	86	81	21.59

The early morning maximum especially noticeable in August is a more or less local effect, due to nighttime thunderstorms off the Caribbean. There is also a local effect in the afternoon maximum, depending upon the distance of hill areas acting as centers of thunderstorm formation.

The general character of the November rains is clearly indicated. There is no sharp morning maximum, but rains are considerably above the average from midnight to 9 a. m., and the afternoon maximum, so marked a feature of the other months, has almost disappeared. The distribution for May and August is characteristic of rains of local thermal origin. The rainfall for March is confined to the light squalls of the trade-wind season. The maxima seem closely associated with the daily minimum temperature and the daily maximum velocity of the wind.

#### NORTHERLY AND OTHER HIGH WINDS

*Historical northerly.*—Unlike the intensified trades, all available evidence indicates that destructive northerly are not associated with well-established trades. They are invariably preceded for several days by light southerly or variable winds. Their development is rapid, which perhaps accounts for much of the damage done. In the old days in Colon Harbor, before the construction of the breakwaters, steam vessels were usually able to put to sea after the storm started, but sailing ships were frequently caught and wrecked. Most of the shore damage was done by sailing vessels being wrecked and driven by the waves into the wharves along the water front, destroying them and ruining the cargo stored thereon.

The historical northerly were probably remembered more for the damage they caused than for their meteorological associations. Ten of these storms occurring between 1857 and 1906 are specifically listed in the MONTHLY WEATHER REVIEW for November, 1917, referred to above.

One of these storms, that of October, 1865, would seem to be open to question. In the French classification the statement is made that the wind was from the southwest and that the storm lasted only six hours with \$300,000 damage. In the issue of October, 21 1865, of the Panama City Star and Herald we find this description. The storm is spoken of as a temporal or tempest and is described as the most severe storm in many years. "It commenced on the night of the 17th, continued during the 18th and 19th, and partially subsided on the 20th. The wind blew a perfect gale and the rain, with short intermissions, fell in torrents." It specifically states that the storm was also felt on the Atlantic side of the Isthmus, but that no material damage was done in Colon. The sea in Panama Bay was described as very rough, local vessels being unable to reach the small islands close offshore for several days, and that a steam vessel with great

<sup>3</sup> Whenever and wherever the southeast quadrant of a well-organized anticyclone meets and merges with the northeast trades the velocity of the latter must be temporarily increased. The suggestion is made, however, that both intensified trades and northerly belong to the same generic class although possessing distinctive features that warrant separate classification.—Ed.

difficulty escaped going on the rocks at Taboga Island. Evidently the wind was southerly. This storm could not be rightfully classified as a norther, but might have been associated with hurricane formation.

In describing damage due to the above storm it was probably confused in the tabulation with the storm of January 18-19, 1873. The *Star* and *Herald* of January 21, 1873, says: "Fearful norther began 11 p. m. on the 18th. Three-masted schooner *Royal Arch* wrecked and carried through Pacific Mail wharf. Loss to cargo and damage to wharf, \$300,000." In the issue of January 25 it states that many more ships were lost, three men drowned, and total damage on the Colon water front estimated at one-half million.

The issues of the *Star* and *Herald* for December 4 to 9, 1885, has the following to say about the norther of that year: "Terrible gale from the northeast began at noon the 2d. Before the storm the wind changed from southwest through west to north. Wharf No. 4 almost demolished. Fourteen sailing vessels lost in Colon Harbor." The great loss of life on the wrecked vessels is deplored, the waves being so high it was impossible to rescue the crews.

**Classification of high winds at Colon, 1908-1926.**—For the last 19 years, 1908-1926, inclusive, detailed data concerning wind direction and velocity during and preceding these storms are available. If the statements of old-timers can be credited, no storms during this period have equalled the intensity of the storms of past years.

While northers have characteristic peculiarities of both wind and other elements, any classification from the meteorological standpoint would have to be based on wind velocity. Any arbitrary standard adopted would be based on a proper relation with average wind conditions and should be sufficiently high to include only periods worthy of note. Such classification, however, would necessarily include many periods of high winds lacking in the other characteristics of northers. The highest mean for any month in the 19-year period is 18.3 miles per hour in February, 1923, during which month no norther occurred. This would indicate that velocities slightly above 20 miles per hour for several hours during the afternoon would not be unusual. Adopting an arbitrary minimum standard of 25 miles per hour for three consecutive hours, all periods exceeding this limit either in velocity or duration have been considered as worthy of inspection.

In the 19-year record there are only 80 such periods, or an average of 4 per year. Only 7 exceed 10 hours in length, with a maximum duration of 30 hours during the norther of April 3-5, 1915. Only two periods have an average velocity above 30 miles per hour, both occurring during northers. If we combine periods of high winds occurring on consecutive days and consider them for what they really are, separate maxima of the same meteorological formation, the number is reduced to 63. Classified according to their characteristics as intensified trades, northers, or gales, including high winds that can not be included under the other two heads, the distribution is as follows:

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Intensified trades.....	0	0	4	20	11	12	4	51
Northers.....	0	2	2	0	1	0	1	6
Gales.....	2	2	2	0	0	0	0	6
Total.....	2	4	8	20	12	12	5	63

**Intensified trades.**—The intensified trades are confined to the months December to April, inclusive, as would be expected, with the maximum frequency in January. February and March winds, while of higher average velocity, seem to be steadier. General conditions during intensified trades differ in no respect from the hours and days immediately preceding and following, except in a slightly higher wind velocity and a heavier sea.

During the three seasons, 1919-20, 1920-21, and 1921-22, simultaneous wind records are available at both Colon and Cape Mala. In tabulating the Cape Mala record a standard of 35 miles per hour for three hours was adopted as being appropriate to the data and closely comparable with the tabulation of the Colon data. During the three years there are 16 days at Colon and 32 days at Cape Mala with periods of high winds above the limits of the classification. No northers occurred during these years. A summary of the comparison follows. The velocities compared are mean velocities for 24-hour periods, midnight to midnight, for the days on which periods of high winds occurred.

	Days with high winds at—					
	Colon only		Both Colon and Cape Mala		Cape Mala only	
	Colon	Cape Mala	Colon	Cape Mala	Colon	Cape Mala
Number of days.....	8.0	-----	8.0	8.0	-----	24.0
Average velocity (miles per hour).....	21.0	21.2	21.4	24.9	18.1	30.9
Departure preceding day.....	1.5	-0.3	2.1	0.1	-0.4	7.2
Average 8 a. m. barometer.....	.894	.841	.922	.849	.926	.846

The average velocity of the 16 days with intensified trades at Colon exceeds the average velocity of the days immediately preceding by only 1.8 miles per hour. This well illustrates the character of these winds as the maximum of a gradual development.

The average departure at Cape Mala for the 32 days is 7.7 miles per hour, showing considerably greater variability. The barometer at Cape Mala shows little variation and remains very close to the seasonal average, but the Colon barometer displays noticeable peculiarities.

It will be seen in the above tabulation that intensified trades at Colon alone are associated with a barometer very close to the seasonal average. The increased velocity would seem to be due to a momentum initiated by pressure gradients farther to the north. Intensified trades at Cape Mala, whether occurring at that station only or at both stations simultaneously, are associated with a noticeably increased barometer at Colon, indicating a southward extension of the high-pressure belt.

If so small a number of observations can be considered significant, the relation of increased velocity to pressure distribution would seem to suggest the existence of local areas of intensification along the steeper portions of the pressure slope toward the equatorial trough. Of the 40 days considered intensification occurred at both stations simultaneously on only 8 days, and no relation between the periods at the two stations seems to exist; no progressive movement or extension of the intensification areas either north or south is indicated. The evidence would seem to support the view that a large percentage of intensified trades are a more or less local phenomenon.

**Gales.**—Of the six periods of high winds mentioned above under the classification "Gales" two each occurred during the months October, November, and December.

One of these periods, that of October 18, 1908, with the wind from the southeast and a maximum velocity of 30 miles per hour was associated with hurricane formation.

Three of these periods occurring on November 16, 1916, November 4, 1917, and October 22, 1923, were westerly gales preceded by light southerly winds. They resembled northers in everything except the wind direction and the heavy sea. The first of these closely followed the formation of a tropical cyclone in latitude 12° N. and longitude 80° W. on November 11, 1916. It was accompanied by moderately heavy rains. The second was a very similar formation. The third, on October 22, 1923, was a culmination of a two-day period of west and northwest gales on October 22 and 23, closely following a four-day period of strong southerly winds on October 16 to 19. It was associated with the heaviest rainfall of record on the Canal Zone.

The other two periods occurred on December 28, 1921, and January 1, 1922. They were intensified trades in their association except that they were accompanied by heavy rain squalls.

**Northers.**—Of the six northers occurring during the 19-year period, two each occurred in the months of November and December and one each in February and April. A tabulation of the mean daily values of wind velocity and direction, barometer, and rainfall at Colon, preceding and following these storms is given herewith. All values are for a 24-hour period, midnight to midnight. The mean barometer is the mean of the bihourly values of the even-numbered hours.

Date of norther	Daily means	Number of days before and after appearance						
		3	2	1	0	1	2	3
Nov. 17, 1912	Velocity	9.4	6.7	4.3	16.1	20.8	19.9	19.2
	Direction	SE.	SE.	Variable	WNW.	NW.	NW.	WNW.
	Barometer	.80	.86	.92	.90	.88	.86	.85
	Rain	.04	.12	.01	.02	.31	.12	.48
Nov. 24-25, 1917	Velocity	7.2	11.2	18.1	27.3	22.7	11.9	12.3
	Direction	SW.	WSW.	NW.	NW.	NW.	NW.	NE.
	Barometer	.90	.88	.89	.94	.91	.89	.87
	Rain	1.02	.79	1.09	.26	1.27	1.08	.63
Dec. 3, 1910	Velocity	9.5	12.1	11.1	20.7	7.3	10.2	6.4
	Direction	8. NW.	WNW.	Variable	N.	NE.	SW.	Variable
	Barometer	.81	.84	.84	.86	.84	.79	.84
	Rain	3.05	2.14	.24	.91	2.51	.01	.05
Dec. 10, 1914	Velocity	8.8	5.8	10.0	20.8	10.7	10.3	8.3
	Direction	WSW.	Variable	Variable	NE.	NE.	NE.	SW.
	Barometer	.80	.78	.79	.78	.76	.78	.79
	Rain	0	0	0	.02	.02	2.22	1.09
Feb. 9, 1915	Velocity	11.0	13.6	16.0	18.6	15.7	21.3	21.0
	Direction	Variable	Variable	NNW.	NW.	N.	N.	N.
	Barometer	.88	.86	.88	.86	.86	.90	.88
	Rain	.31	.92	.01	1.46	7.12	1.69	.02
Apr. 3-5, 1915	Velocity	9.0	6.7	8.4	12.5	32.0	23.4	17.5
	Direction	N.	Variable	SE. W.	Variable	N.	N.	N.
	Barometer	.82	.84	.85	.90	.95	.90	.88
	Rain	0	0	0	4.98	.52	.91	0

In the northers of 1912 and 1914 winds above 25 miles per hour obtained for only three hours. The duration was not long enough to develop any very heavy sea.

The norther of 1910 lasted for 10 hours. Light southerly winds on the forenoon of December 2 shifted to north during the afternoon and evening and increased in velocity. The period of high winds lasted from midnight to 10 a. m. the 3d. The sea was very rough, all large vessels left their berths at the Colon docks, and local water transportation and ship sailings were interrupted.

In the norther of November 24-25, 1917, velocities above 25 miles per hour obtained for 29 hours, from 3 a. m. the 24th to 8 a. m. the 25th, with a maximum velocity of 42 miles from the northwest. This is the second highest velocity in the 19-year record at Colon.

The sea was very rough, but no material damage was done in Colon Harbor.

The dry season of 1915 was abnormal throughout.<sup>4</sup> The trades were never firmly established and the winds were characteristic of early December. The two northers of that year were unusual both as to time of occurrence and as to characteristics. Only once before since 1857 is any mention made of a norther occurring after the 1st of February.

The first one started on February 9, the wind increasing to above 25 miles per hour for four hours from 4 to 8 p. m. The early morning of the 10th the wind fell off and shifted to east and southeast, accompanied by very heavy rain. Seven and twelve one-hundredths inches fell in Colon on that day. By the night of the 10th the wind had shifted back to north with increasing velocity, attaining velocities above 25 miles per hour for five hours on the 11th from 5 to 10 p. m.

The second norther of 1915 began on April 3. Winds above 25 miles per hour lasted for 30 hours from 10 p. m. the 3d to 9 a. m. the 5th, with an average of 31 miles. The highest velocity was attained from 1 to 4 a. m. the 4th, with an average of 38 miles per hour and a maximum of 46 miles. This storm constitutes the record at Colon for both the daily mean and the maximum velocities. The high winds were preceded by light southerly winds and a thunderstorm. For the hour 3 to 4 p. m. of the 3d, only six hours before the norther had attained high velocities, the wind averaged only 3 miles from the south.

The two northers of 1915 were the most violent of the 19-year period and were the only ones causing any great damage in Colon Harbor. According to annual report of the Governor of the Panama Canal, the damage to the east breakwater, under construction, in these two storms was estimated at \$370,000, and to the west breakwater, completed, at \$100,000.

Northers would seem to be more closely related to the westerly gales mentioned above than to any other local meteorological formation. They are entirely distinct from intensified trades. The highest wind velocities at Colon, both momentary and average, have occurred in these storms, and they are the only storms that have caused any great damage. We have positive evidence that one of the northers under consideration, that of February, 1915, was a local storm, not being noticeable over 50 or 100 miles offshore. Reports from captains of incoming vessels during this period were to the effect that no rough weather had been experienced in the Caribbean. The steamship *Alliance* docking at 4 p. m. February 10, did not encounter rough seas until within 50 miles of Colon at noon of the same day. This suggests that all of them might be more or less local.<sup>5</sup> Their rapid development and quick subsidence and the wind shifts always associated with them would also suggest this. Their location on the immediate front of the northeast trades is evident. While their cause is probably an unusual flow of air from the north, the manifestations of strong winds, squalls, and rough seas which we designate by the term "norther" may be local phenomena.

<sup>4</sup> The year 1915 was abnormal over a large part of the Northern Hemisphere; the summer in the United States was unusually cool.

The northers of Feb. 9 and Apr. 3 at Colon doubtless were occasioned by great anticyclones on the several dates which stretched from the Great Lakes southward to an indeterminate distance over the Gulf of Mexico.—Ed.

<sup>5</sup> Since the high pressure that induces the northerly winds advances from west to east, it may well have been that the *Alliance* met the advancing wave of high pressure but 50 miles distant from Panama. The author in a letter to the editor makes it clear that he considers the pressure distribution to the northward as the prime factor in norther causation; nevertheless, the local pressure distribution is also a contributing cause, and it was in this sense that the suggestion was made that northers might be more or less due to local phenomena.—Ed.

# SOUTHERLY WINDS AT THE ISTHMUS OF PANAMA AND TROPICAL CYCLONES

*Periods of constant southerly winds, 1908-1926.*—Southerly winds make up a substantial proportion of the total wind movement at Colon during all of the rainy-season months, but they usually appear only as the land breeze component in the daily variation. When they attain sufficient strength and steadiness to overcome the influence of the sea breeze and blow continually without shift for 24 hours or longer they seem worthy of note.

A tabulation of all days at Colon during the 19-year period, 1908-1926, inclusive, in which the wind blew continually from southerly directions (E., SE., S., and SW.), with a mean velocity of 7 miles per hour or more, may be summarized as follows:

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Total number of days.....	10	18	1	8	35	60	27	0	159
Number of periods of consecutive days.....	8	14	1	7	21	29	17	0	97
Number of periods associated with hurricane formation.....	0	4	0	1	3	10	5	0	23

These figures show an average of only about 8 days a year on which the wind blows continually from southerly directions. The periods range in length from 1 to 6 days. There were 12 periods of 3 days or over. Ten of these were associated with cyclone formation in the western Caribbean. The two exceptions are September 10-12, 1924, and October 16-19, 1923.

On September 13, 1924, a disturbance appeared in the southeastern Gulf of Mexico, developing gale force on the Florida coast. About the right time interval existed for a mild cyclonic disturbance to drift from the southwestern Caribbean, on the 10th or 11th, across Yucatan, and its true nature be identified in the southeastern Gulf on the 13th.

Closely associated with the second instance was the development of a mild disturbance north of the east end of Cuba on October 22, 1923. About the right time interval existed here also. Apparently conditions were not favorable for the development of hurricane force in low latitudes. This suggests the development of other storms farther to the south than first reported and their true character established.

A study of the above tabulation would indicate that if the wind at Colon holds steadily to southerly directions for one day there is one chance in four that a tropical disturbance develops in the western Caribbean; if southerly winds persist for two days, the chances are two in five; and for three days or longer, it is almost conclusive evidence that at least a mild cyclonic circulation has developed.

In tabulating the Cape Mala data a standard of 13 miles per hour without shift from southerly directions (S., SW., and W.) was adopted as being appropriate to the data and roughly comparable with the Colon tabulation. For the three-year period, 1919, 1920, and 1921, for which comparable data are available, there were 20 days at Colon and 39 days at Cape Mala within the limits of the respective classifications. On 23 days southerly winds appeared at Cape Mala only; on 16 days they also extended north as far as Colon. The remaining four days at Colon were associated with constant southerly winds at Cape Mala, but with a less velocity than 13 miles per hour.

From the above it would appear that southerly winds are noticeable at Cape Mala first, that about half the time they also extend northward to Colon, and that their constancy and velocity is considerably greater at the former station.

During the years 1922-1926, inclusive, free-air data at the naval air station at Coco Solo are available on 26 days with constant southerly winds at Colon. In all of these observations, with one exception, southerly winds persisted to the highest level attained, 3,500 meters. The average direction, however, varied from southeast at the surface to south-southwest at the 2,500-meter level. The maximum velocity was attained between the 500 and the 750 meter levels, decreasing below surface velocity near the 2,000-meter level.

From the above it would appear that these periods of southerly winds represent a northward flow of air over a large area, deriving their initial momentum from pressure conditions in the South Pacific; that they are not surface winds, but extend upward to at least 3,500 meters; that their direction at upper levels is close to south-southwest or southwest, near the surface direction at Cape Mala; and that the Isthmus of Panama is near their northern limit. On these occasions when they extend across the Isthmus to the southwestern Caribbean and persist for a few days they seem to be intimately associated with the development of tropical cyclones in those waters.

## TROPICAL CYCLONES, 1908-1926

Of the 30 tropical cyclones forming in the western Caribbean during the 19-year period, 1908-1926, inclusive, 14 were identified as such south of latitude 15°, or within 300 miles of Colon. The average wind and barometer conditions at Colon during the formation and development of these 14 storms is shown in Figure 10. As will be seen, an increase in velocity and southerly winds and a decrease in barometer is noticeable from the third day before the storm is first reported. Northerly winds are negligible throughout the 10-day period considered and southerly winds are well above the average even six days before the storm. The highest velocity and the lowest barometer occur on the day of reported formation, but the maximum of southerly winds does not occur until the day following.

No marked change occurs in the average wind velocity or in the barometer for the 16 storms first reported north of latitude 15°, but a marked preponderance of southerly winds obtains throughout the 10-day period, with a slight maximum the second day before the storm is first reported.

The arbitrary classification used above does not bring out the significant facts in all cases. When storms form east of the eightieth meridian, southerly winds at Colon may shift to west, returning to southerly as the storm advances northward. The storm of November 22, 1909, was immediately preceded by a marked preponderance of westerly winds of high velocity, shifting to southward the day following its formation. This storm is reported as forming in latitude 11° N. and longitude 78° W., very nearly northeast of Colon. Similar conditions accompanied the formation of several other November storms.

Of the 30 storms under consideration, 24 were associated with days of constant southerly winds at Colon. Of the remaining 6, 5 were first reported north of latitude 17° and west of longitude 82°, or more than 500 miles from Colon and outside the southwestern Caribbean.

The remaining storm is the one mentioned above, of November 22, 1909, when the usual southerly winds were replaced by westerly.

During the three-year period for which records are available at Cape Mala three tropical cyclones occurred. The first one was reported September 19, 1920, in  $16^{\circ}$  N. and  $85^{\circ}$  W. Constant southerly winds blew at Cape Mala for the four-day period, September 17-20, inclusive, and at Colon for the two days, September 17-18. The second was reported on June 15, 1921, in  $14^{\circ}$  N. and  $81^{\circ}$  W. At Cape Mala southerly winds blew for two days, the 16th and 17th, and at Colon for one day, the 16th.

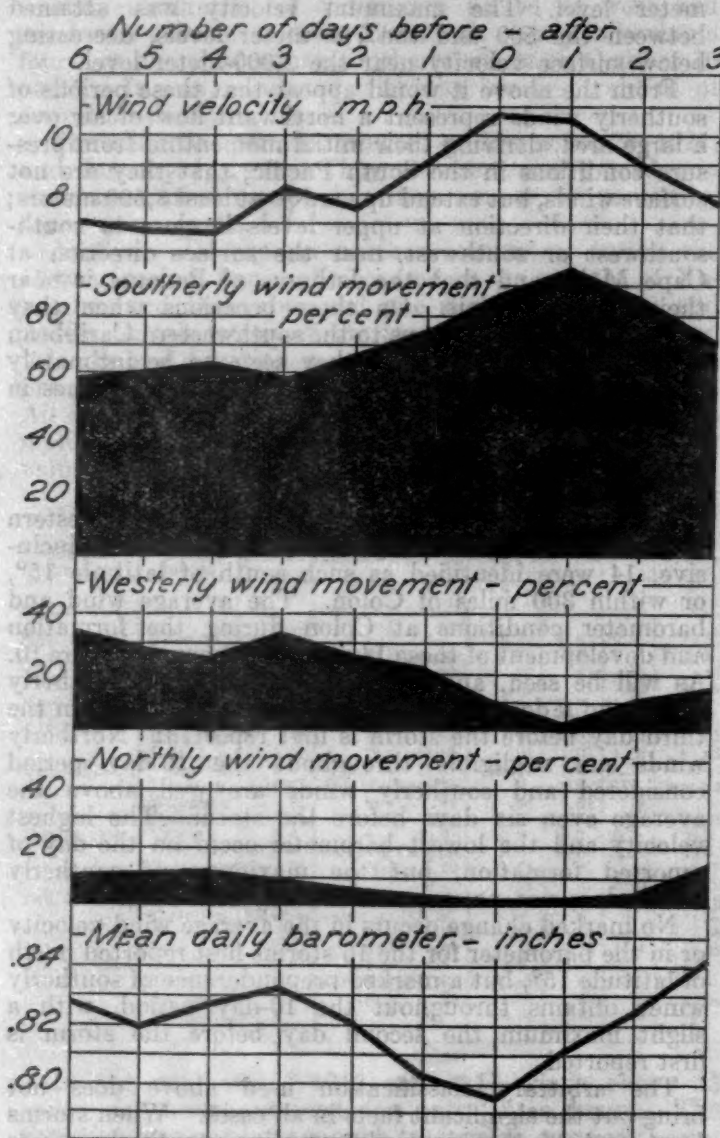


FIG. 10.—Mean daily wind and barometer at Colon for 10-day period at time of formation of tropical cyclones in western Caribbean south of latitude  $15^{\circ}$  N.

The third storm was reported on October 21, 1921, in  $14^{\circ}$  N. and  $81^{\circ}$  W. At Cape Mala the wind blew constantly from southerly points for seven days, the 18th to 24th, inclusive, with daily means ranging from 14 to 21 miles per hour. At Colon southerly winds obtained for four days, the 18th to 22d, inclusive, with daily means ranging from 7 to 18 miles per hour.

Free-air data at Coco Solo are available during the formation of two tropical cyclones. At the time of the formation of the cyclone of October 17, 1924, in  $15^{\circ}$  N. and  $84^{\circ}$  W., observations are available from the 13th to the 18th and up to the 3,000-meter level. Velocities

were light at all levels. The direction at the surface was southeast and south-southeast and mostly south to southwest above 1,000 meters.

Several balloon flights to 1,500 meters are available near the time of formation of the cyclone of October 17, 1926, in  $12^{\circ}$  N. and  $80^{\circ}$  W. October 16, at 7 a. m., the wind varied from SE. 8 at the surface to a maximum of S. 31 at 750 meters and SSW. 28 at 1,500 meters. October 18, at 7 a. m., the velocity was SE. 19 at the surface and held at SSE. 34 at the 500, 750, and 1,000 meter levels. By 7 a. m. the 19th the wind had fallen to ESE. 9 at the surface, SE. 26 at 500 meters, and SE. 19 at 1,500 meters.

#### RELATION BETWEEN SOUTHERLY WINDS AND HURRICANE FORMATION

In a comparison of southerly winds at Colon with the time of hurricane formation it is noted that for storms first reported north of latitude  $15^{\circ}$  the maximum of southerly winds at Colon usually precedes the first report by one or two days; but for storms originating south of latitude  $15^{\circ}$ , or within 300 miles of Colon, the maximum usually occurs on the day of reported formation or the day following. In other words, as far as the near-by storms are concerned, a cyclonic circulation actually exists and has been identified as such before the maximum of southerly wind occurs at Colon.

A comparison of all available records at Colon and Cape Mala indicates that the initial momentum of these southerly winds originates somewhere in the South Pacific, and that they extend northward with diminishing velocity, and are entirely independent of the existence of any cyclonic formation, but that the appearance of any pronounced maximum at Colon is dependent upon the development and northward progress of a cyclonic circulation. According to fishermen and turtlers familiar with the southwestern Caribbean, the most obvious feature locally at the time of the formation of a tropical cyclone is frequently the southeast gales that persist, sometimes for several days, after the storm has passed. It would appear that the existence of a following wind in the wake of the moving storm, but distinct from the cyclonic circulation itself, is a reality, and that the influence of this wind in intensifying the already existing southerly winds over the Isthmus of Panama produces the comparatively high velocities which is their most noticeable feature.

#### THE WEATHER OF 1927 IN THE UNITED STATES

By ALFRED J. HENRY

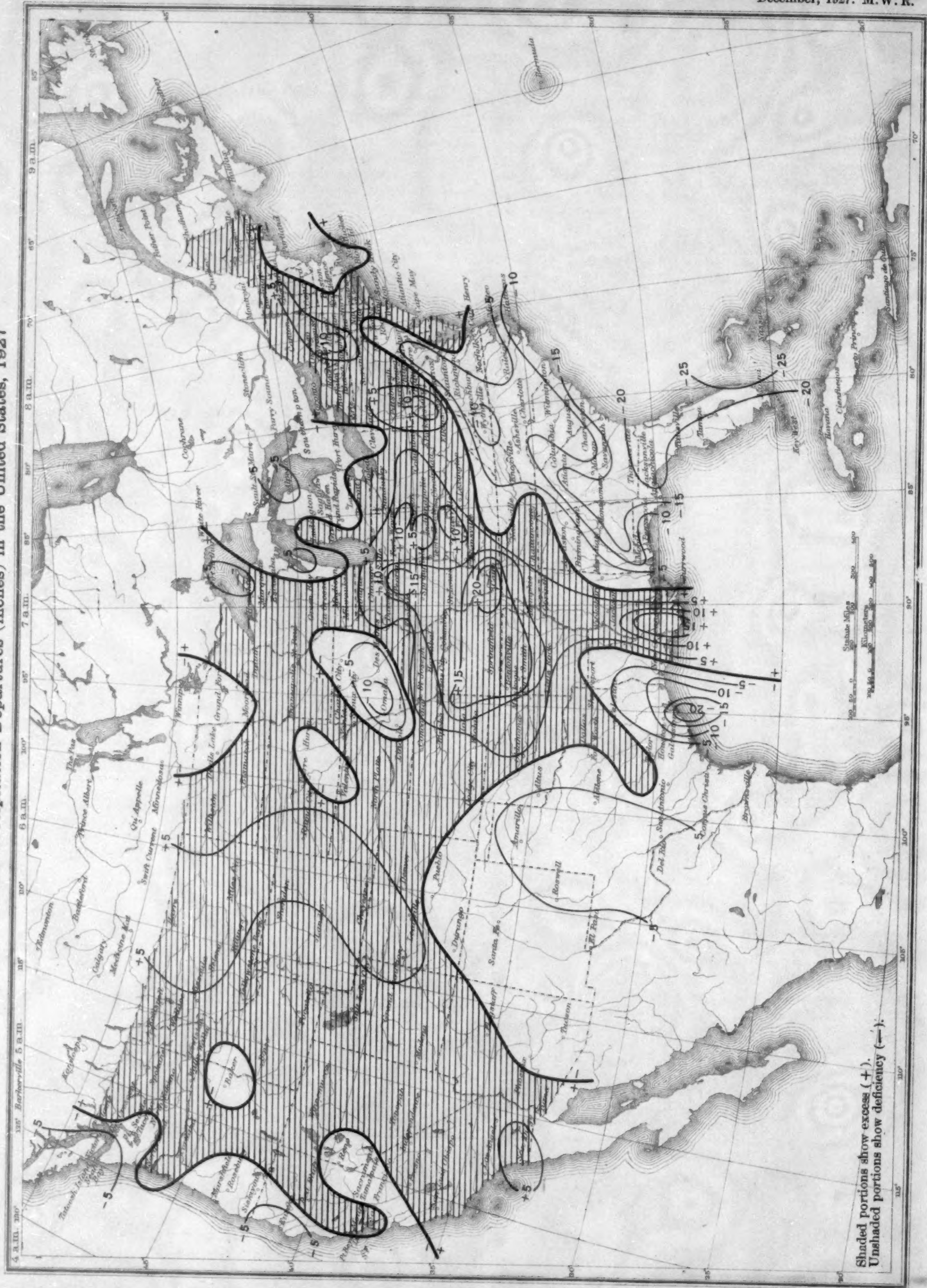
Tables 1 and 2 below contain the statistics of the two most important climatic elements, temperature and precipitation, for 1927.

Weather Bureau officials have sought for a number of years a method of presenting the climatic statistics of continental United States as a single geographic unit in a more satisfactory manner than is now followed. The difficulty lies in the greatly different physiographic features of the several divisions of the area and the unequal distribution of meteorological stations therein. Readers of the Review will recognize in Tables 1 and 2 the same geographic districts as are carried in Table 1 of the MONTHLY WEATHER REVIEW. It is therefore a matter of the saving of much labor to present in a single table the mean values for the several districts combined in an annual mean. It is granted that the combination of the 21 district means into a single mean is meaning-

I. Annual Temperature Departures (°F.) in the United States, 1927



# II. Annual Precipitation Departures (inches) in the United States, 1927



Shaded portions show excess (+).  
Unshaded portions show deficiency (-).

less, nevertheless it affords a ready means of comparing one year with another and that is the chief reason for continuing the practice.

Whatever method of determining the annual means of temperature and precipitation be adopted it is clearly shown by the figures of Table 1 that the year as a whole was a warm one in practically all parts of the country. (Chart 1.)

For precipitation, however, the statistics of Table 2 as presented on chart 2 seems to be at variance with the very general impression that the early part of the year, at least was unusually wet in the Mississippi Basin.

It is not possible to get from Table 2 any clear view of the rainfall distribution in the Mississippi Basin because the geographic districts in that table not only do not coincide with those within that basin but also they con-

tain large areas without the basin in which precipitation was as a rule deficient. The Atlantic coast States and the East Gulf States had greatly reduced rainfall in the great majority of months of 1927, one great rainstorm in western New England in November being an exception.

The year was rather rich in calamitous events due to atmospheric phenomena; a single tornadic storm swept through a closely built up section of St. Louis, Mo., causing a large number of deaths and injuries and a vast property loss. Two calamitous floods, one in the Mississippi Basin, the other in western New England, completed the record of the year.

While unfavorable weather at times was harmful to crops favorable weather later in the season made up the damage and the final result was a crop yield above the 10-year average.

TABLE 1.—Monthly and annual temperature departures, 1927

District	January	February	March	April	May	June	July	August	September	October	November	December	Average monthly departure
New England.....	+1.6	+3.3	+4.7	+0.2	-2.2	-2.3	-0.4	-2.9	+0.8	+3.4	+5.5	+2.7	+1.2
Middle Atlantic.....	0.0	+0.6	+4.2	-1.3	-1.2	-3.5	-0.9	-4.6	+1.1	+2.6	+4.5	+1.8	+0.3
South Atlantic.....	+0.8	+8.9	+2.2	+1.3	+1.5	-1.2	-0.8	-1.6	+2.1	+2.3	+4.1	+0.2	+1.6
Florida Peninsula.....	-0.2	+5.7	+0.6	+2.2	+2.4	+2.6	+1.3	+1.4	+0.3	+0.2	+1.4	-0.2	+1.5
East Gulf.....	+3.0	+8.7	+1.0	+1.0	+1.4	0.0	+0.2	-0.8	+2.3	+2.6	+5.4	-0.8	+2.2
West Gulf.....	+3.4	+6.2	+0.3	+3.7	+3.3	-0.8	-0.3	+0.6	+1.6	+3.3	+7.4	-3.0	+2.1
Ohio Valley and Tennessee.....	+0.7	+7.8	+3.6	+1.3	-0.5	-3.8	-0.8	-4.8	+3.2	+3.1	+4.8	-0.6	+1.2
Lower Lakes.....	-0.4	+5.9	+5.7	-0.1	-2.1	-4.2	-1.1	-4.4	+2.6	+3.4	+4.4	+0.9	+0.9
Upper Lakes.....	-0.9	+6.0	+6.9	+0.7	-2.3	-2.7	-1.6	-3.8	+3.2	+3.1	+0.9	-2.9	+0.6
North Dakota.....	+5.8	+5.8	+8.6	+1.5	-5.7	-1.2	-2.7	-1.6	+0.4	+4.2	-5.5	-13.5	-0.3
Upper Mississippi Valley.....	+0.9	+8.8	+5.7	+0.3	-2.3	-3.3	-1.7	-4.0	+3.4	+3.7	+1.9	-4.9	+0.7
Missouri Valley.....	+3.9	+8.5	+3.4	+1.6	-1.1	-2.1	-1.4	-4.2	+1.9	+4.6	+0.1	-8.1	+0.6
Northern Slope.....	+1.7	+3.7	+1.7	-1.3	-3.0	-0.6	-0.8	-2.7	-1.3	+4.0	+0.2	-11.6	-0.8
Middle Slope.....	+3.8	+5.8	-1.0	+2.2	+2.4	-1.4	-1.0	-4.7	0.0	+4.2	+3.5	-5.6	+0.7
Southern Slope.....	+3.1	+5.4	+0.2	+3.9	+5.6	-0.4	0.0	+1.6	+0.6	+2.9	+7.5	-4.2	+2.1
Southern Plateau.....	+4.7	+3.9	-0.4	+1.2	+1.9	-0.1	+1.3	-0.6	0.0	+1.6	+4.5	-2.5	+1.3
Middle Plateau.....	+3.9	+3.4	-0.3	-0.4	-0.6	+1.5	+2.0	-1.4	-1.5	+2.6	+4.6	-3.9	+0.8
Northern Plateau.....	+1.4	+4.4	-0.4	-1.8	-2.8	+1.6	+2.0	+0.6	-2.4	+2.7	+4.3	-0.5	+0.3
North Pacific.....	+0.9	+2.7	-0.4	-0.2	-1.0	+1.9	+1.2	+1.5	+0.7	+1.7	+1.7	-3.3	+0.6
Middle Pacific.....	+1.5	+1.7	-0.6	+0.3	-0.2	+1.0	+0.9	-0.5	-0.4	+1.4	+1.2	-1.0	+0.4
South Pacific.....	+1.5	+1.7	-0.2	+0.2	+0.9	-0.6	+0.9	-0.7	-1.6	+2.0	+2.9	+0.2	+0.6
United States.....	+2.0	+5.5	+2.2	+0.9	-0.3	-0.9	-0.2	-1.8	+0.8	+2.8	+3.1	-3.2	+0.9

TABLE 2.—Monthly and annual precipitation departures, 1927

District	January	February	March	April	May	June	July	August	September	October	November	December	Accumulated departures for the year
New England.....	-0.9	-0.6	-2.3	-1.6	-0.4	-0.5	+0.8	+2.7	-0.9	+0.6	+2.3	+1.2	+0.4
Middle Atlantic.....	+1.7	-0.1	+2.1	+0.2	-0.5	-0.4	+0.3	+0.5	-1.3	+2.8	+0.4	+1.2	-0.7
South Atlantic.....	-2.7	-0.7	-1.1	-1.6	-2.4	+0.3	-0.2	-1.0	-2.8	-0.6	-1.1	+1.9	-12.0
Florida Peninsula.....	-1.8	+0.1	-0.9	-1.0	-3.9	-4.1	-1.1	-2.0	-2.3	-0.2	-1.8	-1.0	-20.0
East Gulf.....	-3.9	+2.3	-0.9	-0.6	-1.2	+0.9	-1.1	-0.8	-2.2	-0.9	-0.1	+2.7	-5.8
West Gulf.....	-0.9	-0.3	+0.1	+1.6	-1.4	+1.4	-0.3	-1.4	-0.9	+0.7	-1.4	+1.2	-1.6
Ohio Valley and Tennessee.....	+0.3	-0.4	+1.5	+2.1	+1.2	-0.8	-0.1	-0.6	-0.4	0.0	+1.6	+0.3	+4.7
Lower Lakes.....	-0.9	+0.2	-0.4	-0.4	-0.6	-1.7	+0.7	-0.8	-1.0	+0.1	+4.4	+0.7	+0.3
Upper Lakes.....	-0.8	-0.5	-0.2	+0.3	+0.7	-1.3	+0.5	-2.0	+0.9	+0.6	+1.1	+0.7	0.0
North Dakota.....	-0.1	0.0	0.0	0.0	+2.5	-0.6	-1.2	+0.6	-0.5	+0.1	0.0	+0.4	+1.2
Upper Mississippi Valley.....	-0.1	-0.6	+1.6	+1.3	+2.1	-0.6	-1.3	-1.1	+2.2	+0.9	+0.7	+0.4	+6.5
Missouri Valley.....	-0.2	-0.4	+1.8	+2.4	0.0	-0.1	-0.8	+0.9	0.0	+0.5	+0.1	+0.1	+4.3
Northern Slope.....	-0.3	-0.1	-0.1	+0.5	+1.3	-0.3	-0.1	+1.0	+0.8	+0.2	+0.6	0.0	+3.5
Middle Slope.....	-0.2	+0.2	+0.8	+1.0	-2.4	+0.8	+0.3	+2.5	+0.4	+0.5	-0.6	-0.2	+3.1
Southern Slope.....	-0.4	+0.4	-0.5	+0.1	-2.4	-0.9	-0.9	-0.6	+0.1	-0.9	-1.1	-0.4	-7.5
Southern Plateau.....	-0.6	+0.3	-0.1	-0.1	-0.3	+0.4	-0.4	0.0	0.0	-0.1	-0.4	+0.2	-1.1
Middle Plateau.....	-0.3	+0.5	+0.6	-0.5	0.0	+0.4	-0.1	+0.4	+0.7	+0.3	+0.4	+0.1	+2.3
Northern Plateau.....	0.0	+0.2	-0.2	-0.5	-0.3	+0.3	-0.2	+0.1	+2.3	0.0	+1.6	-0.6	+2.7
North Pacific.....	-0.5	+1.3	-1.0	-0.9	+0.1	-0.6	-0.4	+0.1	+1.0	+1.0	+1.4	-3.6	-2.1
Middle Pacific.....	+2.5	+2.5	-2.0	-0.2	-0.6	+0.1	0.0	0.0	-0.4	+0.1	+0.3	-1.2	-2.6
South Pacific.....	-1.2	+4.0	-0.7	-0.1	-0.5	0.0	0.0	0.0	-0.1	+1.4	-0.6	+0.7	+2.9
United States.....	-0.9	+0.4	-0.3	+0.1	-0.4	-0.3	-0.3	-0.1	-0.2	+0.3	+0.4	+0.2	-1.1

## NOTES AND ABSTRACTS

## WILLIAM HENRY DINES, 1855-1927

[Condensed from the Meteorological Magazine, January, 1928]

The readers of this magazine will have heard with regret of the death of W. H. Dines, which occurred on Christmas Eve at the Old Observatory, Benson, and will desire to express their sympathy with Mrs. Dines and with her two sons who are our colleagues on the staff of the office.

Interest in meteorology may almost be said to be hereditary in the Dines family, for Mr. Dines's father was the inventor of the dew-point hygrometer, which still goes by his name and is described in most text books on physics. \* \* \*

Mr. W. H. Dines was born in 1855. He served an apprenticeship as a railway engineer, and then proceeded to Corpus Christi College, Cambridge, where he read mathematics and graduated as a Wrangler in 1881. From that time onward he devoted himself to meteorology but did not hold an official position. He was in the true and best sense of the word an amateur, never seeking to enhance his personal reputation, still less to secure financial advantages for himself, but he has left an indelible impress on the progress of the science. Of an exceedingly reticent and retiring nature, he was essentially an individual worker, yet a great deal of his work was done in cooperation with others. His early work on wind pressure was in cooperation with the Wind Pressure Committee of the Royal Meteorological Society. It gave us the pressure-tube anemometer, which made it possible to measure transient gusts of wind, an indispensable preliminary to the development of our modern ideas of turbulence.

Dines had reached middle life when the observational study of the upper air came into its own. \* \* \* The Joint Upper-Air Committee of the British Association and the Royal Meteorological Society, which was responsible for inaugurating such work as could be undertaken here, was fortunate in securing Dines as its active worker. The early work was carried out with kites at Mr. Dines's house at Oxshott, or from a steam vessel off Crinan on the west coast of Scotland. He exhibited an almost uncanny facility in devising at a minimum of cost, apparatus which worked and achieved results which he had set out to obtain. \* \* \* The investigation of the higher regions of the atmosphere by means of sounding balloons was included in a [later] program. Here Dines struck an entirely original line in the design of the meteorograph which he used. To economize weight he dispensed with the clock, which was used by all other workers in the field, and contented himself with obtaining a pressure-temperature record of the ascent on a scale so small that the curve had to be tabulated with the help of a reading microscope. \* \* \*

In his later years he was impelled to the study of radiation, and here again we find him active both as a designer of instruments and as observer and student. It is gratifying to note that despite his failing health he was able to maintain his scientific interests almost up to the end, for it is only a few months since he contributed, with the cooperation of his son, L. H. G. Dines, a paper to the *Memoirs of the Royal Meteorological Society* on "Mean values of radiation from various parts of the sky at Benson." Mr. Dines was elected a Fellow of the Royal Meteorological Society in 1905, and was awarded the Symon's gold medal of the Royal Meteorological Society in 1914.—R. G. K. Lempfert.

GENERAL JADWIN REPORTS ON FLOOD-PROTECTION SYSTEM FOR MISSISSIPPI RIVER<sup>1</sup>

Flood-protection works costing \$296,400,000 for the Mississippi Valley are recommended in the long-awaited report of Maj. Gen. Edgar Jadwin, Chief of Engineers, United States Army, just transmitted to Congress by the President with his indorsement. The recommendations represent a thoroughgoing revision of the present Mississippi River Commission's project as well as of the system under which work has been carried on heretofore. Depending on levees only is for the first time abandoned, and declared to be incapable of providing for the maximum predicted flood. The essentials recommended are:

## THE PROJECT IN OUTLINE

(1) The present levee system is retained as the basis of the new project, but the levees are to be raised somewhat and at some points are to be set back. To prevent failure from causes other than overtopping and bank caving the levee section is to be enlarged. The maximum section, generally, will be river slope 1 on 4, crown 12 feet wide, and landside slope about 1 on 6.

(2) Three large overflow channels or flood ways outside the levee lines are to be provided, all on the west side of the river, located as shown on the map, Figure 3.

(3) Just above New Orleans a controlled spillway into Lake Pontchartrain is to be built.

(4) Backwater ponding in the lower ends of the principal flood basins is utilized for further relief, these backwater areas being submerged only in occasional floods from once in 3 years to once in 15 years.

(5) Bank revetment on a large scale (to cost \$115,000,000 is provided for channel stabilization.

(6) A complete topographic map of the valley is to be prepared as a preliminary, and the estimates included a figure of \$1,000,000 for this work.

As to the administrative system which should be set up for carrying out this great project, General Jadwin recommends that the local authorities be required to meet part of the construction cost—\$37,440,000 out of the total figure stated above—and in addition all costs of right of way and incidental damages, while the United States Government should pay the rest. Direction of the work by the Mississippi River Commission is to be improved by placing the commission under the direction of the Chief of Engineers.

In connection with these specific recommendations, the report discusses various alternative solutions that have been proposed and finds against them. In particular it states that reservoirs would not be capable of dealing with the flood problem at any reasonable cost.

No details on the determination of maximum probable flood are given in the report, nor is levee construction discussed except to say that the earth levee is the best type for the purpose. The plans and estimates do not include the tributaries except for a short distance above their mouths; the subject of tributaries is still under study.

At the outset the report declares that the past plans of the Mississippi River Commission have been proved unsuccessful:

<sup>1</sup> Reprinted from Engineering News-Record of December 13, 1927.

The plan heretofore pursued has been the construction of levees high enough and strong enough to confine all of the flood waters within the river channels. The levees that have been constructed are not sufficiently high for such floods as are now predicted. \* \* \* Insufficient room was left in the river for the passage of the unprecedented volume of flood water. The levees must be strengthened, but a halt must be called on further material increase in their heights and the consequent threat to the inhabitants of the areas they are built to protect.

Man must not try to restrict the Mississippi River too much in extreme flood. The river will break any plan which does this.

The plan recommended provides the requisite space for the passage of floods, and levees of adequate strength to withstand them.

#### NEW THREE-CUP ANEMOMETER

The new three-cup anemometer has been furnished to each first-order station in continental United States. These instruments were put into use as station anemometers beginning with January 1, 1928.

This anemometer runs so close to the true velocity of the wind that errors in the anemometer itself are smaller in magnitude than errors from other sources, such as those due to exposure, variability in velocity during the time period chosen, the mechanical condition of the anemometer, and limitations in making and interpreting the record. Hence, the indicated values from the new instrument will be recorded, reported, and published without correction. A brief description of the instrument is published in the MONTHLY WEATHER REVIEW for April, 1924, pages 216-218.

At evaporation stations where, because of the location of the anemometer near the ground, the velocities are so low as to be practically the same from either the four-cup or the three-cup instrument, the four-cup instrument will be continued.

#### HOW SUNSPOTS ACT AS REFRIGERATORS<sup>1</sup>

[Reprinted from the Literary Digest, January 21, 1928, p. 36]

It seems to be the fashion to blame sunspots for the weather. It is true that the researches of Abbot and his coworkers appear to indicate that the sun gives off a slightly greater amount of heat when spots are most numerous, but the observations are delicate and the reality of the phenomenon may still be questioned by some. Other attempts to correlate the spots with rainfall have led to conflicting results and, though men have seriously tried to figure a relation between sunspots and the trend of stocks, the price of wheat, famines, etc., it should be obvious that if so direct an effect as rainfall is uncertain, secondary effects would be even less connected. It is not impossible that the yearly average rainfall of the entire earth may some day be found dependent upon the frequency of sunspots, but as to local conditions, the possibility of predicting the weather from the spot configurations, we are more than skeptical—frankly unbelieving.

#### SNOW AND A COLD WAVE IN EUROPE DECEMBER 18-23, 1927

Coincidentally with the occurrence of a cold wave in Europe on the dates above mentioned, there was an exceptionally large depression of the barometer over the North Atlantic, apparently extending from Newfoundland to Portugal, or it may be that a greater number of meteorological reports would have shown the presence of a series of great barometric depressions in tandem; in any event, the contrast between the pressure over the ocean and the land was unusually great.

It is a rather common experience to find in the Pacific Ocean a great barometric depression coincidentally with the presence of a great anticyclone over continental United States. During the period above mentioned there was a fairly intense cyclone centered over the Gulf of Alaska, but high pressure over the continent prevented its advance inland. The weather in the

United States during the cold wave in Europe changed but little, high pressure dominating throughout the period.—A. J. H.

#### THE INFLUENCE OF FORESTS ON RAINFALL AND RUN-OFF<sup>1</sup>

C. E. P. BROOKS, D. Sc.

[Reprinted from Meteorological Magazine, December, 1927]

Of the water vapor which is condensed as rainfall over the land, about two-thirds is provided by evaporation over the oceans, and the remaining third by evaporation and transpiration over the land. The latter contribution is made up of the evaporation of rainfall intercepted by foliage, evaporation from the soil, and transpiration, and estimates are made of these three factors for forests, crop or grass land, and bare soil. The figures are expressed as percentages of an average rainfall of 30 inches a year; for forests they give interception, 15; evaporation from soil, 7; transpiration, 25; total, 47 per cent. For crops evaporation from soil, 17; transpiration, 37; total, 54 per cent. For bare soil, evaporation, 30 per cent. Thus, the replacement of forests by crops would tend to increase the supply of moisture to the air, and, therefore, the general rainfall slightly; replacement by bare soil would decrease the general rainfall slightly. The changes in the run-off are likely to be more noticeable; replacement of forests by crops would decrease the run-off by 15 per cent, and make it less regular; replacement by bare soil would increase the run-off, but would make it highly irregular. A forest 30 feet high may be considered as adding about 30 feet to the effective height of the ground, and this should increase the local orographical rainfall by 1 or 2 per cent. Data obtained in various localities were examined in detail. At Mauritius, deforestation has resulted in a decrease by 2 or 3 per cent, while in Sweden, Germany, and India the rainfall at forest stations is about 1 per cent greater than that at neighboring stations in the open, after making allowance for differences of exposure. The question of fog and dew was also examined, and it was found that under average conditions their total effect is slight.

#### METEOROLOGICAL SUMMARY FOR SOUTHERN SOUTH AMERICA, NOVEMBER, 1927

By J. BUSTOS NAVARRETE, Director

[Observatorio del Salto, Santiago, Chile]

Atmospheric circulation showed but little activity in November. In the central region the weather was very variable, with much cloudiness and morning fog on the coast. Rains were infrequent in the south; the storms developed, as usual, in the region from Valdivia to Chiloe and at times extended as far as Concepción and Maule.

The most important anticyclones, accompanied by fair weather in the south, strong south winds on the coast between Chiloe and Arauco, and general fall in temperature, were those of the 1st-3d, 6th-13th, and 19th-25th. The second of these developed in the region of Juan Fernandez, moved toward Chiloe, and then recurved toward the Atlantic coast over Neuquen, Bahia Blanca, and Buenos Aires.

Small depressions were frequent on the coasts of the middle region and the Province of Coquimbo; important depressions accompanied by strong winds and rain crossed the southern region between the 4th and 6th and about the 11th.

<sup>1</sup> The Literary Digest of Jan. 21, 1928, quoting from Dr. Donald H. Menzel, of Lick Observatory, in one of the leaflets of the Astronomical Society of the Pacific, remarks upon the very great contrast in temperature between the temperature of the photosphere and that of the spot itself, viz, about 2,000 deg. (absolute) lower. The excerpt which we print below will doubtless be of interest to our readers.—Editor.

<sup>1</sup> The full article of which the following is an abstract will doubtless appear in a forthcoming number of the Quarterly Journal of the Royal Meteorological Society, 49 Cromwell Road, London, S.W. 7.

## BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

## RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

- Alippi, Tito.  
Come è organizzato e come funziona l'Ufficio presagi. Roma. 1927. 4 p. 34 cm.
- Atwood, R. E., comp.  
Stories and pictures of the Vermont flood, November, 1927. [Burlington. c1927.] 32 p. illus. 27 cm.
- Austin, L. W.  
Long-wave radio measurements at the Bureau of Standards in 1926, with some comparisons of solar activity and radio phenomena. p. 825-836. figs. 23 cm. (Repr.: Proc. Inst. radio eng., Oct., 1927.)
- Bates, D. C.  
Climate of New Zealand. Wellington. 1927. 16 p. figs. 24½ cm. (Extr.: New Zealand official year-book, 1928.)
- Bureau, Robert.  
Les atmosphériques. Paris. n.d. p. 301-346. figs. 24 cm. (L'Onde électrique 5<sup>e</sup> année. N° 55. Juil., 1926.)  
Recherches sur la structure électromagnétique des discontinuités de l'atmosphère. 16 p. figs. 27½ cm. (Extr.: La Mét., T. 3, nouv. sér., juil. 1927.)
- Bureau, Robert, & Coyecque, M.  
Les croisières radiométéorologiques du "Jacques-Cartier." Paris. 1926. 92 p. plates (fold.) 31½ cm. (Aeron. et trans. aériens. no. 17, Mém. de l'Off. nat. de France.)
- Chu, Coching.  
Preliminary study on the weather types of Eastern China. 6 p. plates. 28 cm.
- Cooper, F. L.  
Windmill electric generators. unip. plates. 23 cm. (Col. agric. coll. Exten. serv., circ. no. 10, March 1926.)
- Cortés, Victoria Zárate.  
Elementos genéticos del clima de Lima breves notas a cerca de algunos de los mas importantes. Lima. 1926. v. p. diagrs. 33½ cm. (Trab. presentado a la Soc. nac. agraria.)
- Díaz, Severo.  
Nueva meteorología. pt. I. Hechos fundamentales. Guadaluajara. 1927. 48 p. illus. 28 cm.
- Dorno, C.  
Grundzüge des Klimas von Muottas-Muraigl (Oberengadin). Eine meteorologisch-physikalisch-physiologische Studie. Braunschweig. 1927. x, 177 p. illus. table (fold.) 22½ cm.  
Physikalische Grundlagen der Sonnen- und Lichttherapie. 15 p. figs. 22½ cm. (Sonderdr.: Medizinischen Welt, 1. Jahrg. Nr. 35 vom 1. Oktober 1927.)  
Physiologische Wirkungen der Luftelektrizität. 8 p. 24½ cm. (Sonderab.: Zeitschr. für wissensch. Bäderkunde. 1927. H. 2.)
- Eredia, F.  
Il nuovo meteorografo dell' Ufficio presagi. Pisa. 1927. 6 p. illus. 23½ cm. (Estr.: L'Aeroteca, Giorn. ed atti dell'Ass. ital. di aerotec. Anno 6, N. 9, 1927.)  
Sui dispositivi e sui sistemi adottati nei lanci di palloni sonda. Pisa. 1927. 8 p. figs. 23½ cm. (Estr.: L'Aeroteca, Giorn. ed atti dell'Ass. ital. di aerotec., Anno 6, N. 9, 1927.)
- France. Office national météorologique.  
Atlas des postes et stations. Paris. n.d. unp. figs. 23½ cm.
- Hakonson-Hansen, M[artin] K[ristian].  
Trondhjemsvær, resultat av de meteorologiske observasjoner i Trondhjem i tiåret 1916-1925. Trondhjem. 1927. 53 p. 24 cm.
- [Hamburg.] Deutsche Seewarte.  
Wetterkunde und Wetterkarte. Anleitung zum Gebrauch der Wetterkarte und zu Wetterbeobachtungen nebst Anhang einer Wolkenkarte in Mehrfarbendruck. Hamburg. n.d. 36 p. figs. plates. 22½ cm.
- Hornar, Donald W.  
Weather observations and aids to forecasting. London. [1927.] 64 p. illus. front. 19 cm.
- Japan. Imperial marine observatory.  
Mean atmospheric pressure, cloudness and sea surface temperature of the North Pacific ocean and the neighbouring seas for the year, 1926. Kobe. 1927. 122 p. plates. 26½ cm.

- Kousnetzov, B.  
Atlas des nuages. Éd. 2. Leningrad. 1926. 26, 24 p. plates. 13 cm. (Obs. géophys. cent.) [Author, title and text in French and Russian.]
- Marshall, Robert.  
Influence of precipitation cycles on forestry. p. 415-429. figs. 23 cm. (Repr.: Journ. of forestry, v. 25, no. 4, Apr., 1927.)
- Mexico. Servicio meteorológico.  
La temperatura en la ciudad de Mexico, D. F. durante 50 años de 1877 a 1926. Tacubaya. 1927. 46 p. plates. 28 cm.
- Mörkofer, Walter.  
Der tägliche Gang der Bewölkung zu Basel. Basel. 1927. p. 427-453. figs. 23 cm. (Separatab.: Verhandl. der naturf. Gesellsch. in Basel. Bd. 38.)
- Palmén, E.  
Über die Bewegung der aussertropischen Zyklonen. Helsingfors. 1926. 102 p. figs. plates (fold.) 24 cm. (Soc. scient. Fennica. Comm. phys.-math. III. 7.)
- Vanderlinden, Emile.  
Sur la distribution de la pluie en Belgique. Bruxelles. 1927. 50 p. figs. plates. 32 cm. (Inst. roy. mét. de Belgique. Mém. v. 2.)
- Wada, Koroku, & Nisikawa, Syōdirō.  
Measurement of variable velocity relative to air with Pitot-static tube. [Tōkyō. 1927.] p. 327-396. figs. plate (fold.) 26 cm. (Rep. Aeron. res. inst., Tōkyō imp. univ., no. 27. Nov. 1927. (v. 2, 13.))

## RECENT PAPERS BEARING ON METEOROLOGY

The following titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

- Akademie der Wissenschaften. Sitzungsberichte. Wien. Abt. IIa. Band 136, Heft 3 u. 4. 1927.
- Benndorf, Hans. Grundzüge einer Theorie des elektrischen Feldes der Erde. II. p. 175-194.
- American meteorological society. Bulletin. Worcester, Mass. v. 8. 1927.
- Clayton, H. Helm. A method of verifying weather forecasts. p. 144-146. (Oct.)
- Clayton, H. H[elm]. The weather of 1927 as related to solar changes. p. 152-153. (Oct.) [Abstract.]
- Loveland, George A. Definite short range weather forecasting. p. 153-156. (Oct.) [Abstract.]
- McEwen, George F. Indications of the (1927 to 28) seasonal rainfall in southern California. p. 157-158. (Oct.)
- Boerema, J. Rainfall types in the Netherlands East-Indies. p. 167-168. (Nov.) [Abstract.]
- Chu, Coching. A preliminary study of the weather types of eastern China. p. 164-167. (Nov.)
- Cressy, George B. The climate of the glacial period in eastern Asia. A statement of the problem. p. 170. (Nov.) [Abstract.]
- Huntington, Ellsworth. The weather and human progress. p. 159-164. (Nov.) [Abstract.]
- Lowdermilk, Walter C. Factors influencing surface run-off of rainfall. p. 169-170. (Nov.) [Abstract.]
- Another meteorological caterpillar. p. 183-184. (Dec.)
- Talman, C. Fitzhugh. A caterpillar weather prophet (?). p. 182-183. (Dec.)
- Talman, C. Fitzhugh. Preparing for snow removal. p. 181-182. (Dec.)
- Typhoid fever and rainfall. p. 184-186. (Dec.)
- Weather observations for auto testing. p. 178-179. (Dec.)
- Annalen der Hydrographie und maritimen Meteorologie. Berlin. 65. Jahrgang. 1927.
- Groissmayr, Fritz. Spezialklimatologische Untersuchung der Winterniederschläge Westlands. p. 291-293. (September.)
- Markgraf, H. Zur Frage der Blitzgefährdung von Flugzeugen. p. 281-286. (September.)

*Annalen der Hydrographie und maritimen Meteorologie*—Contd.

- Perlewitz, P. Ist das Fliegen heute unabhängig vom Wetter? Welche Rolle spielt der Wind beim Fliegen? p. 286-290. (September.)
- Grosse, W. Statistische Berechnungen der Winde für Bremen. p. 321-323. (Oktober.)
- Perlewitz, P. Zur Regenverteilung auf dem Atlantischen Ozean. p. 331-332. (Oktober.) [With rainfall chart for July.]
- Perlewitz, P., & Ahlgrimm, [Fr.] Wissenschaftliche Freiballonfahrt mit Funkbild-Übertragungsversuchen. p. 316-321. (Oktober.)
- Astronomical society of the Pacific. Publications. San Francisco. v. 39. December, 1927.*
- Johnson, James Halvor. On the altitude of the aurora. p. 347-350.
- Beiträge zur Geophysik. Leipzig. 18. Band, 3. Heft. 1927.*
- Baur, Franz. Zusammenhänge des Witterungscharakters des März in Deutschland mit der gleichzeitigen und der vorausgegangenen Luftdruckverteilung. p. 225-246.
- Götz, F. W. Paul. Strahlungsmessungen in Montana (Wallis) durch Prof. A. Gockel. p. 262-265.
- Pollak, Leo Wenzel. Verallgemeinerte Isobaren. p. 292-312.
- Electrical world. New York. v. 90. August 27, 1927.*
- Peek, F. W., jr. Protection from lightning. II. p. 408-412.
- Engineering news-record. New York. v. 99. 1927.*
- General Jadwin reports on flood protection system for Mississippi River. p. 961-966. (Dec. 15.) [Abst. in this review.]
- Stuhrman, E. A. Repair of hurricane damage to two Miami buildings. p. 1050-1053. (Dec. 29.)
- France. Académie des sciences. Comptes rendus. Paris. t. 185. 1927.*
- Devaux. Sur la mesure de la densité des champs de neige et des glaciers. p. 1147-1149. (21 novembre.)
- Lavauden, L. Quelques effets de la sécheresse sur les vertébrés supérieurs de l'Afrique du Nord. p. 1210-1212. (28 novembre.)
- Hobbs, William Herbert. Les expéditions au Groenland de l'Université de Michigan. p. 1294-1296. (5 décembre.)
- Devaux, Joseph. Sur la formation des glaciers par fusion diurne et regel nocturne des névés. p. 1602-1604. (27 décembre.)
- Hemel en dampkring. Den Haag. 25 jaargang. December 1927.*
- Albada, L. E. W. van. Stereoscopische wolkenopnamen. p. 372-379.
- Időjárás. Budapest. v. 51. Szeptember-október 1927.*
- Hille, A. Meteorologische Beobachtungen während des Fluges. p. 158. [Abstract.]
- Imperial academy. Proceedings. Tokyo. v. 3. October, 1927.*
- Kaburaki, Tokuni. Notes on the protective value of wind-breaks. p. 561-563.
- Marine observer. London. v. 5. January, 1928.*
- Smith, H. T. The extraction and compilation of marine meteorological data by mechanical methods. p. 10-14.
- Meteorologia pratica. Montecatini. Anno 8. Maggio-giugno 1927.*
- Bilancini, Raoul. Contributo allo studio della influenza della radiazione sul clima. p. 110-112.

*Meteorologia pratica*—Continued.

- Bilancini, Raoul. Contributo allo studio della variazione del clima. p. 108-109.
- Crestani, Giuseppe. Le trombe in Italia nel 1926. p. 113-114.
- Crestani, G., & Paoloni, B. Ciò che insegnano i recenti voli transatlantici. Di navi aeroporti. Stazioni radiometeorologiche su gli oceani. p. 115-131.
- Majo, Ester. Composti azotati disciolti nella pioggia a Portici. p. 105-107.
- Martinozzi, Leonardo. Le stagioni piovose delle Isole Britanniche. p. 132-134.
- Norske videnskaps-akademi. Geofysiske publikasjoner. Oslo. v. 4, no. 3. 1927.*
- Gaarder, Torbjörn. Die Sauerstoffverhältnisse im östlichen Teil des Nord-Atlantischen Ozeans.
- Port-au-Prince. Observatoire météorologique. Séminaire-Colège St.-Martial. Bulletin annuel. Port-au-Prince. 1925.*
- Baltenweck, R. Le P. Ignace Scherer. p. iii-vi. [Obituary. With portrait.]
- Reale accademia dei lincei. Atti. Roma. Rendiconti. v. (6) 6. 1927.*
- Baruzzi, M. Andamenti periodici della temperatura media diurna a Modena. p. 46-49. [Fasc. 1-2.]
- Eredia, F. La direzione risultante dei venti alle varie altezze desunta dalle osservazioni di paoloni piloti eseguite a Vigna di Valle (Bracciano). p. 49-53. [Fasc. 1-2.]
- Ruda, F. Sulla spiegazione del raggio verde. p. 152-165. [Fasc. 5-6.] p. 228-230. [Fasc. 7-8.]
- Revue de géographie alpine. Grenoble. t. 15. 1927. fascicule 2.*
- Gex, F. Le climat de 1926 en Savoie. p. 317-335.
- Royal meteorological society. Quarterly journal. London. v. 53 October, 1927.*
- Angström, Anders. On the unit of radiation in meteorological treatises on actinometry. p. 448-449.
- Bower, S. Morris. Report on winter thunderstorms in the British Islands from January 1st to March 31st, 1926. p. 421-438.
- Chree, C. The effect of pressure on the readings of thermometers. p. 438.
- Jeffreys, Harold. Cyclones and the general circulation. p. 401-406.
- Meyer, George M. Early water-mills in relation to changes in the rainfall of East Kent. p. 407-419.
- The range of atmospherics. A report from the Committee on the relation between atmospherics and weather. p. 327-400.
- Treloar, H. M. The variation of eddy viscosity with wind velocity and season. p. 439-445.
- A waterspout off the Needles. p. 420.
- Watson, R. A. Nephoscope observations at Mauritius. p. 446-448.
- Sociedad científica "Antonio Alzate." Memorias y revista. México. Tomo 47. 1927. Núms. 1-4.*
- Gallo, Joaquin. Las manchas solares y las lluvias en la ciudad de México. p. 55-59.
- Zeitschrift für Physik. Berlin. 42. Band. 1. Heft. 1927.*
- Cario, Günther. Die Wellenlänge der grünen Nordlichtlinie. p. 15-21.

## SOLAR OBSERVATIONS

## SOLAR AND SKY RADIATION MEASUREMENTS DURING DECEMBER, 1927

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, 52:42, January, 1925, 53:29, and July, 1925, 53:318.

Table 1 shows that solar radiation intensities were above the normal values for December at all three stations except during afternoons at Madison, Wis., and Lincoln, Nebr.

Table 2 shows a slight excess in the total solar radiation received on a horizontal surface directly from the sun and diffusely from the sky, at all three stations for which normals have been determined, as compared with the December normals for these stations.

Skylight polarization measurements at Washington made on six days give a mean of 52 per cent, with a maximum of 57 per cent on the 5th. These are considerably below the corresponding normal values for Washington for December. At Madison the ground was covered with snow during most of the month and in consequence no skylight polarization measurements were made.

TABLE 1.—Solar radiation intensities during December, 1926

[Gram-calories per minute per square centimeter of normal surface]

## WASHINGTON, D. C.

Sun's zenith distance												
Date	75th mer. time	Air mass									Local mean solar time	
		A. M.					P. M.					
		e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
		mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Dec. 5		4.37	0.81	0.98	1.09	1.28		1.31	1.13	0.99	0.81	4.57
6		3.81	0.84	0.99	1.09	1.19						4.75
7		3.24					1.37	1.22	1.12	1.01		3.00
8		2.79	0.87	0.99	1.17	1.37		1.17	1.01	0.87		0.86
9		2.38	0.73	0.85	0.99	1.25		1.10	0.96			1.37
10		1.88	0.94	1.06	1.20	1.38		1.17	1.07	0.93		1.88
11		1.52										1.12
12		1.07	0.50	0.75	0.92	1.08		1.00				2.87
13		2.36										2.15
14		3.30										3.15
Means			0.80	0.94	1.05	1.27		(1.34)	1.13	1.03	0.90	
Departures			+0.01	+0.04	+0.03	+0.04			+0.10	+0.12	+0.11	

## MADISON, WIS.

Date	1.32	1.08	1.18	1.28	1.30	1.51	1.27	1.04	1.21	1.96
Dec. 2	1.78	1.08	1.18	1.28	1.30	1.51	1.27	1.04	1.21	1.96
20	1.78	1.08	1.18	1.28	1.30	1.51	1.27	1.04	1.21	1.96
21	1.68	0.85	1.02	1.15						
22	1.45	1.00	1.11	1.24	1.38	1.53	1.21			
Means	0.98	1.10	1.24	(1.38)	(1.53)		1.17			
Departures	+0.02	+0.00	+0.02	+0.06			-0.10			

## LINCOLN, NEBR.

Date	0.86	1.19	1.39	1.49	1.60	1.01	1.01	0.92	0.71
Dec. 8	0.86	1.19	1.39	1.49	1.60	1.01	1.01	0.92	0.71
9	0.81	1.01	1.14			1.09	0.95	0.77	1.78
14	3.15	0.81	1.06	1.16					4.75
15	0.96	1.07	1.20	1.33	1.64	1.19	1.05	0.86	
16	0.91	0.86	1.09					1.12	
17	0.96	1.00	1.21	1.29	1.36	1.16	0.99	0.96	
18	0.86	1.00	1.12	1.31	1.50			0.81	
19	1.07	1.11	1.22			1.17	1.03	0.98	0.96
20	1.52	1.07	1.15						1.96
Means	0.96	1.09	1.23	1.45	(1.62)	1.11	1.04	0.93	
Departures	+0.02	+0.03	+0.00	+0.06		-0.09	-0.03	-0.03	

\* Extrapolated.

TABLE 2.—Solar and sky radiation received on a horizontal surface

[Gram-calories per square centimeter of horizontal surface]

Week beginning	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1927									
Dec. 3	150	125	185	97	105	171	+8	+8	+15
Dec. 10	124	74	183	47	73	132	-17	-44	+10
Dec. 17	182	151	195	78	141	182	+39	+26	+26
Dec. 24	143	85	172	66	112	182	-1	+40	-7
Deficiency at end of year							-8,415	-5,618	-7,035

## POSITIONS AND AREAS OF SUN SPOTS

Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory

Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson observatories

Data	Eastern standard civil time	Heliographic		Area <sup>1</sup>		Total area for each day
		Longi-tude	Lat-i-tude	Spot	Group	
1927						
Nov. 8 (Harvard)	13 15	-23.0	-8.0	153		153
Nov. 10 (Harvard)	10 45	-72.0	+5.5	97		
		-67.0	-5.0	795		
		-17.5	+7.5	159		
		+2.0	-8.0	1,082		2,183
Nov. 23 (Harvard)	14 00	+3.0	-15.5	1,194		
		+14.0	-13.0	64		
		+18.5	-13.0	165		
		+51.5	+11.5	436		
Dec. 1 (Naval Observatory)	11 51	+68.0	-5.3	244		2,103
		-37.0	+13.5	6		
		-33.5	-11.0	15		
		+25.0	-15.5	77		
		+74.0	-18.0	93		
Dec. 2 (Mount Wilson)	11 40	+85.0	-16.0	463		654
		-75.0	+7.0	39		
		-55.0	-14.0	24		
		-20.0	-10.0	31		
Dec. 4 (Mount Wilson)	14 15	+39.0	-14.0	35		123
		-25.0	-21.0	22		
		+66.0	-14.0	3		23
Dec. 5 (Naval Observatory)	11 42	-83.0	+18.5	62		
		-42.5	-11.5	31		
		-14.5	-22.0	108		201
Dec. 6 (Naval Observatory)	11 42	-75.0	-10.5	154		
		-74.0	+18.5	62		
		-66.5	+19.0	62		
		-29.0	-12.0	62		
		-5.0	-21.5	46		
Dec. 7 (Harvard)	14 45	+0.5	-21.0	62		448
		-60.0	-10.5	468		
		-55.0	+18.5	162		
		-9.5	-10.5	100		
		+15.0	-21.5	68		
Dec. 8 (Naval Observatory)	11 36	+29.0	+11.5	161		908
		-77.0	+4.5	123		
		-49.5	-11.0	62		
		-47.5	+19.0	31		
		-42.5	-9.5	77		
		-37.5	+19.5	46		
		-3.0	-11.5	62		
		+2.0	-11.0	62		
		+6.0	-9.5	46		
		+22.0	-22.0	31		
Dec. 9 (Naval Observatory)	11 41	+28.5	-21.5	31		571
		-64.5	+5.0	139		
		-37.5	-10.5	46		
		-34.0	+19.5	31		
		-29.5	-8.5	46		
		-25.0	+20.0	46		
		+9.0	-11.0	123		
		+14.5	-10.0	170		
		+44.5	-11.0	37		
Dec. 10 (Naval Observatory)	11 41	+48.0	-10.0	31		669
		-50.5	+5.0	139		
		-23.0	-10.5	31		
		-17.5	-8.5	46		
		+21.5	-12.0	247		
		-26.5	-13.0	46		
		-29.0	-9.5	123		
		+55.0	-19.5	31		
Dec. 12 (Harvard)	14 40	+58.5	-12.0	46		700
		-22.0	+4.5	49		
		+13.0	-6.5	171		
Dec. 14 (Naval Observatory)	11 37	+54.5	-10.0	1,864		2,684
		+2.5	+5.0	139		
		+14.5	-15.0	6		
		+39.0	-9.0	25		
		+73.0	-14.5	216		
		+77.0	-12.0	62		448

<sup>1</sup> Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column.

Positions and areas of sun spots—Continued

Date	Eastern stand-ard civil time	Heliographic		Area		Total area for each day
		Longi-tude	Lat-i-tude	Spot	Group	
1927						
Dec. 15 (Mount Wilson)	14 30	-64.0	+17.0	3		
		+18.0	+4.5		141	
		+56.0	-7.0		21	165
Dec. 16 (Mount Wilson)	18 0	+24.5	+5.0		136	
		+63.0	+13.0	12		
		+63.0	-8.0		19	167
Dec. 17 (Naval Observatory)	11 39	+44.0	+5.0	77		77
Dec. 18 (Naval Observatory)	11 51	+53.0	+6.0		62	62
Dec. 19 (Naval Observatory)	11 50	-14.0	+15.5	15		
		-11.0	+15.5		15	
		+70.0	+5.0		62	92
Dec. 20 (Naval Observatory)	11 42	-2.5	+15.5	15		
		+0.5	+15.0		31	46
Dec. 21 (Naval Observatory)	14 12	+14.0	-16.0	62		
		+17.5	-15.0		31	93
Dec. 22 (Naval Observatory)	13 10	+27.5	-16.0	15		
		+30.0	+14.5		46	61
Dec. 23 (Naval Observatory)	11 55	-21.5	+19.5	9		
		+13.0	-11.5		46	
		+13.5	+19.5		15	
		+24.0	-13.0		31	
		+40.0	+16.5		31	
		+42.0	+15.0		77	
		+46.0	+14.0	15		224
Dec. 24 (Naval Observatory)	11 45	-34.5	+10.5		46	
		-9.0	+20.5	12		
		-4.5	+19.0	6		
		+10.5	-13.0		62	
		+23.5	-11.0		46	
		+29.5	-11.5		37	
		+53.0	+17.0		46	
		+55.0	+15.0		77	
		+60.0	+14.0	15		347
Dec. 25 (Naval Observatory)	11 46	-25.0	+14.0		93	
		-20.5	+11.0		31	
		+0.0	+20.0		6	
		+9.5	+19.0		9	

Positions and areas of sun spots—Continued

Date	Eastern stand-ard civil time	Heliographic		Area		Total area for each day
		Longi-tude	Lat-i-tude	Spot	Group	
1927						
Dec. 25 (Naval Observatory)	11 46	+22.0	-12.5		31	
		+27.0	-11.5		46	
		+37.5	-11.5		46	
		+43.0	-11.5		77	239
Dec. 26 (Naval Observatory)	11 42	-14.0	+14.5		93	
		-9.5	+13.0		31	
		-7.0	+13.0		108	
		-0.0	+10.0		9	
		+35.0	-12.5		31	
		+40.0	-11.0		62	
		+49.5	-11.5		37	
		+57.5	-11.5		62	433
Dec. 27 (Naval Observatory)	11 43	-72.5	-15.0	139		
		-0.5	+14.5		93	
		+3.5	+12.5		77	
		+8.0	+12.5		154	
Dec. 28 (Naval Observatory)	11 38	+54.0	-11.0	62		325
		-83.0	-9.0	216		
		-70.0	-5.0	46		
		-58.5	-15.5	139		
		+16.0	+15.5		31	
		+17.0	+13.0		93	
		+22.0	+12.5		185	
		+65.0	-11.0	62		772
Dec. 30 (Mount Wilson)	14 45	-54.0	-9.0		534	
		-42.0	-5.0		13	
		-31.0	-15.0		108	
		+46.0	+12.0		260	904
Dec. 31 (Mount Wilson)	14 30	-78.0	-9.0		87	
		-41.0	-9.0		463	
		-29.0	-5.0		6	
		-16.0	-15.0		152	
		+25.0	+8.0		14	
		+50.0	-13.0	4		
		+62.0	+12.0		227	925
Mean daily area for December						450

## AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Free-air temperatures were below normal at practically every level at all stations except Washington. (See Table 1.) Departures were exceptionally large at Ellendale and Broken Arrow. The consistent positive departures at Washington are in close agreement with those shown for this region in Chart 111, as are also the negative departures at the other stations.

As is generally the case when large negative temperature departures occur, the resultant winds contain a much greater northerly component than normally. This was especially pronounced in the lower levels at Ellendale where the largest temperature departures occurred. (See Table 2.) However, negative temperature departures are not always accompanied by an excess of northerly or a deficiency of southerly air movement. An inverse relationship is strikingly shown at Broken Arrow from

750 to 1,500 meters, inclusive, where the resultant winds contained a larger southerly component than normal, although the largest negative temperature departures for this station are found at these same levels. The monthly resultants at the other kite stations were close to normal.

The resultant wind movement as indicated by pilot balloon observations contained a north to west component at the 3,000-meter level over the entire country. At San Juan an easterly component prevailed in the monthly resultants from the surface to 4,500 meters.

Relative humidities averaged unusually high in the upper levels at the two southern stations, Broken Arrow and Groesbeck. This excess of relative humidity resulted in large positive vapor pressure departures in these regions. Both of these stations had a large number of cloudy days during the month.

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during December, 1927

## AEROLOGICAL OBSERVATIONS FOR 1927

By L. T. SAMUELS

TEMPERATURE (° C.)												
Altitude, m. s. l. (meters)	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C.* (7 meters)	
	Mean	De- parture from 10- year mean	Mean	De- parture from 7-year mean	Mean	De- parture from 10- year mean	Mean	De- parture from 10- year mean	Mean	De- parture from 10- year mean	Mean	De- parture from 3-year mean
Surface	0.6	-3.6	5.9	-2.3	-19.0	-9.1	7.5	-1.6	-3.4	-1.5	4.9	+2.7
250	0.5	-2.7	5.8	-2.3	-18.5	-8.7	7.1	-1.8	-3.6	-1.6	3.9	+2.4
500	-0.3	-4.0	5.4	-2.4	-18.5	-8.7	6.5	-1.9	-4.6	-1.4	2.8	+2.4
750	-1.4	-4.9	5.5	-2.1	-15.9	-7.2	6.2	-2.0	-4.8	-1.1	1.9	+2.3
1,000	-1.9	-5.8	5.2	-2.0	-13.1	-5.7	6.7	-1.7	-5.0	-1.3	1.2	+2.1
1,250	-1.6	-5.8	4.7	-1.9	-11.9	-5.1	6.4	-1.7	-5.4	-1.8	0.6	+2.0
1,500	-1.0	-5.0	4.4	-1.4	-11.7	-4.9	5.5	-2.0	-5.7	-2.0	0.4	+2.1
2,000	-1.1	-3.9	3.5	-0.7	-12.1	-4.2	4.5	-1.8	-6.6	-1.7	-0.3	+2.2
2,500	-2.9	-3.6	1.7	-0.6	-13.7	-3.8	3.5	-0.6	-7.7	-1.0	-2.1	+2.0
3,000	-4.8	-3.2	-0.1	-0.4	-16.1	-3.7	1.4	-0.3	-9.5	-0.6	-4.5	+1.9
3,500	-6.7	-2.8	-0.7	-1.1	-17.0	-2.5	-0.5	+0.3	-12.3	-0.7	-7.1	+1.9
4,000	-10.2	-3.5	-2.7	+1.9			-3.1	+0.4	-15.5	-0.7	-10.2	+1.9
4,500	-13.8						-5.6	+0.3	-18.4	-0.6		
5,000		-4.2							-21.3	-0.6		

RELATIVE HUMIDITY (%)												
Surface	65	-5	72	-1	80	-1	66	-8	80	0	66	-1
250	65	-5	71	-1			64	-8	80	0	65	0
500	60	-4	65	-1	78	-1	62	-6	77	-1	63	-1
750	58	-1	61	-2	71	-1	62	-2	73	-1	62	-1
1,000	57	+4	59	-2	65	0	55	-2	67	0	59	-1
1,250	53	-6	61	+1	63	+2	52	-1	62	+1	58	-1
1,500	50	+7	60	+2	61	+3	52	+3	58	0	53	-4
2,000	49	+11	60	+6	59	+4	51	+9	51	-3	49	-6
2,500	45	+16	48	-1	57	+2	55	+16	51	-2	49	-6
3,000	53	+16	45	+2	58	+4	57	+20	51	-2	53	-2
3,500	44	+8	42	-1	67	+13	57	+27	44	-9	56	+1
4,000	56	+20	38	-5			65	+29	46	-11	58	+1
4,500	66	+29					63	+27	33	-23		
5,000									31	-23		

VAPOR PRESSURE (MB)												
Surface	5.03	-1.29	7.54	-1.10	1.09	-1.55	8.27	-1.25	4.15	-0.42	6.48	+1.38
250	5.00	-1.27	7.44	-1.10			7.98	-1.20	4.10	-0.41	6.12	+1.21
500	4.51	-1.09	6.95	-0.92	1.12	-1.45	7.55	-0.88	3.78	-0.21	5.57	+1.06
750	3.79	-1.25	6.70	-0.69	1.32	-1.17	7.39	-0.87	3.77	+0.18	5.17	+0.95
1,000	3.55	-0.93	6.35	-0.49	1.45	-0.96	6.64	-0.28	3.42	+0.16	4.68	+0.90
1,250	3.26	-0.68	6.16	-0.21	1.49	-0.83	6.99	-0.21	3.05	+0.10	4.34	+0.71
1,500	3.21	-0.35	5.81	0.00	1.51	-0.69	5.49	+0.09	2.71	0.00	3.79	+0.45
2,000	3.14	+0.25	4.90	+0.16	1.37	-0.32	5.11	+1.00	2.21	-0.06	3.18	+0.26
2,500	2.99	-0.56	3.60	-0.20	1.16	-0.43	4.97	+1.70	2.09	+0.10	2.83	-0.29
3,000	2.73	+0.65	3.08	+0.09	0.95	-0.32	4.58	+1.92	1.85	+0.14	2.58	-0.58
3,500	2.27	+0.46	2.91	+0.27	0.98	0.00	4.24	+2.16	1.54	-0.12	2.30	+0.82
4,000	2.03	+0.46	2.63	+0.48			4.15	+2.23	1.17	-0.07	2.10	+0.82
4,500	1.83	+0.48					3.91	+2.21	0.91	-0.09		
5,000									0.74	-0.09		

\* Naval air station, Anacostia, D. C.

TABLE 2.—Free-air resultant winds (m. p. s.) during December, 1927

Altitude m. s. l. meters	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)				Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)			
	Mean		10-year mean		Mean		7-year mean		Mean		10-year mean		Mean		10-year mean		Mean		10-year mean		Mean		7-year mean	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	W.	2.0	S. 63°W.	1.1	N. 32°E.	0.7	S. 70°W.	1.2	N. 34°W.	3.9	N. 52°W.	3.4	N. 14°E.	0.8	N. 61°W.	1.0	S. 40°W.	2.5	S. 56°W.	2.3	N. 42°W.	2.6	N. 43°W.	1.5
250	W.	2.1	S. 57°W.	1.3	N. 34°E.	0.7	S. 61°W.	1.3	N. 33°W.	4.2	N. 58°W.	3.8	S. 66°E.	0.8	S. 85°W.	1.1	S. 42°W.	2.8	S. 54°W.	2.6	N. 62°W.	5.4	N. 63°W.	3.7
500	S. 58°W.	2.8	S. 48°W.	3.0	S. 44°W.	0.6	S. 64°W.	3.2	N. 27°W.	4.6	N. 56°W.	5.6	S. 30°W.	2.2	S. 57°W.	2.4	S. 62°W.	5.1	S. 60°W.	5.4	N. 68°W.	7.7	N. 67°W.	6.0
750	S. 48°W.	3.6	S. 53°W.	3.7	S. 69°W.	2.3	S. 70°W.	4.9	N. 24°W.	4.1	N. 56°W.	6.0	S. 47°W.	3.5	S. 60°W.	4.6	S. 62°W.	6.2	S. 69°W.	7.1	N. 68°W.	7.8	N. 69°W.	7.6
1,000	S. 61°W.	4.1	S. 66°W.	4.5	S. 71°W.	3.6	S. 77°W.	6.4	N. 24°W.	4.1	N. 56°W.	7.3	S. 63°W.	4.4	S. 67°W.	5.7	S. 70°W.	7.3	S. 79°W.	8.3	N. 69°W.	8.2	N. 68°W.	8.9
1,250	S. 69°W.	5.6	S. 78°W.	5.1	S. 67°W.	6.3	S. 76°W.	7.9	N. 45°W.	4.9	N. 57°W.	8.1	S. 57°W.	5.4	S. 68°W.	6.6	S. 79°W.	8.6	S. 83°W.	9.8	N. 52°W.	10.1	N. 69°W.	11.2
1,500	S. 69°W.	6.6	S. 79°W.	6.0	S. 66°W.	10.2	S. 82°W.	9.6	N. 49°W.	4.9	N. 57°W.	9.7	S. 73°W.	8.9	S. 77°W.	9.6	S. 79°W.	10.7	S. 88°W.	10.9	N. 52°W.	10.1	N. 69°W.	11.2
2,000	N. 88°W.	9.0	S. 84°W.	7.4	S. 80°W.	11.6	S. 84°W.	11.5	N. 60°W.	6.7	N. 59°W.	9.8	S. 78°W.	5.6	S. 74°W.	7.8	N. 84°W.	11.7	N. 88°W.	12.6	N. 67°W.	11.1	N. 71°W.	12.8
2,500	N. 76°W.	12.6	N. 88°W.	9.7	S. 81°W.	13.7	S. 88°W.	11.9	N. 70°W.	9.7	N. 62°W.	11.6	S. 73°W.	8.9	S. 77°W.	9.6	N. 78°W.	12.0	N. 85°W.	14.3	N. 70°W.	13.5	N. 74°W.	15.4
3,000	N. 79°W.	14.2	N. 89°W.	11.0	S. 78°W.	18.1	N. 87°W.	13.8	N. 72°W.	12.0	N. 65°W.	13.1	S. 79°W.	12.8	S. 78°W.	11.4	N. 75°W.	11.6	N. 88°W.	14.2	N. 78°W.	13.3	N. 76°W.	16.5
3,500	N. 87°W.	17.2	N. 88°W.	12.6	S. 68°W.	14.0	N. 85°W.	14.0	N. 74°W.	16.7	N. 71°W.	14.8	S. 87°W.	14.7	S. 80°W.	12.0	N. 73°W.	9.2	N. 84°W.	13.3	N. 78°W.	16.6	N. 69°W.	18.0
4,000	S. 77°W.	15.7	N. 85°W.	12.1	S. 65°W.	16.0	N. 80°W.	12.9	N. 80°W.	26.1	N. 71°W.	14.0	N. 78°W.	19.4	S. 84°W.	12.0	N. 56°W.	7.2	S. 72°W.	11.6	N. 73°W.	16.3	N. 69°W.	18.5
4,500	S. 77°W.	16.2	N. 86°W.	12.8									N. 45°W.	17.0	N. 83°W.	12.2	W.		S. 64°W.	7.8	N. 74°W.	15.7	N. 75°W.	20.4
5,000																	W.				N. 68°W.	16.7	N. 70°W.	18.8

Resultant velocities exceeded the normals during May, July, and November.

An outstanding feature of the year was the inauguration of free-rising captive-balloon observations. This method has proved valuable when winds are too light for kite flying and contributes to the continuity of daily free-air soundings.

A limiting-height device (Rossby deflation valve) was also used occasionally and the balloon allowed to rise unrestricted by wire. The valve was set so as to deflate the balloon between 2 and 3 kilometers. The balloon's ascent and descent were then followed by means of two theodolites and its recovery effected usually within a very short time.

During October, the International Month for 1927, a series of 44 sounding-balloon observations were made at Groesbeck, Tex. Thus far 34 of the meteorographs have been returned. Practically all of the ascensions were observed with two theodolites to high altitudes which in some cases exceeded 20 kilometers. On October 14 and 15, designated as the International Days, continuous kite flights were made at the aerological stations and 5 airplane soundings at the Naval Air Station, Anacostia, D. C.

A series of sounding-balloon observations were made on December 30 and 31 when 12 Weather Bureau stations released 2 balloons each. Continuous kite flights were also made on the same days at the aerological stations, a series of airplane observations at several naval air stations and special pilot-balloon observations at most of the pilot-balloon stations. This program was carried out in connection with a special study of free-air convection.

During the year there were 1535 kite flights made, averaging 2,685 meters in altitude, 32 captive-balloon observations, nearly 30,000 pilot-balloon observations and 225 airplane observations, the latter at the Naval Air Station, Anacostia, D. C.

## THE WEATHER IN THE UNITED STATES

### GENERAL CONDITIONS

A cold month, particularly in the upper Missouri Valley and adjacent regions as shown by Chart III. Precipitation was on the whole more abundant than for the average December. See the inset on Chart IV. The usual details follow.

### THE WEATHER ELEMENTS

By P. C. DAY

#### PRESSURE AND WINDS

The notable feature of the closing month of 1927 was the persistent and severe cold that prevailed over the northern districts from the Great Lakes westward during the greater part of the first two decades, and to a less extent even during the last. Anticyclones largely dominated the weather over the northwestern districts and few important cyclones entered the country from that section during the latter half of the month until near the end.

Moderately low pressure over the Atlantic Coast States during the first few days caused heavy precipitation from

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during the year 1927

Altitude, m. s. l. (Mean)	TEMPERATURE (°C.)													
	Broken Arrow, Okla. (233 meters)		Dug West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C.* (7 meters)			
	Mean	De- parture from 3-year mean	Mean	De- parture from 7-year mean	Mean	De- parture from 10- year mean	Mean	De- parture from 3-year mean	Mean	De- parture from 10- year mean	Mean	De- parture from 3-year mean	Mean	De- parture from 3-year mean
Surface.....	15.5	-0.1	16.0	-0.1	4.0	-1.5	18.9	+0.7	10.2	-0.3	15.0	.....	.....	.....
250.....	13.4	-0.1	16.6	-0.1	.....	.....	18.4	-0.8	10.0	-0.2	13.2	.....	.....	.....
500.....	14.4	+0.2	15.0	+0.1	3.9	-1.5	17.4	-1.1	9.0	0.0	12.8	.....	.....	.....
750.....	13.6	+0.4	14.0	+0.4	3.7	-1.2	16.5	-1.1	8.0	+0.2	12.3	.....	.....	.....
1,000.....	13.0	+0.6	13.0	+0.5	3.6	-1.0	15.9	-1.2	7.3	-0.5	10.2	.....	.....	.....
1,250.....	12.4	+0.8	11.9	+0.5	3.2	-0.9	15.2	-1.3	6.4	-0.6	9.1	.....	.....	.....
1,500.....	11.6	+1.0	10.6	+0.5	2.5	-0.8	14.3	-1.3	5.4	-0.6	8.1	+1.9	.....	.....
2,000.....	9.3	+0.9	8.1	+0.4	0.3	-0.9	12.2	-1.3	3.1	-0.4	6.0	-2.0	.....	.....
2,500.....	6.7	+0.9	5.7	+0.3	-2.3	-0.9	9.5	-1.3	0.8	-0.5	3.7	-2.0	.....	.....
3,000.....	3.8	+0.8	3.5	+0.8	-5.2	-1.0	7.1	-1.1	-1.6	-0.6	1.1	-2.1	.....	.....
3,500.....	1.1	+0.9	1.2	+1.2	-7.9	-0.9	4.6	-1.3	-4.2	-0.6	-1.1	-2.9	.....	.....
4,000.....	-2.0	+0.7	-1.2	+1.6	-10.8	-1.0	1.6	-1.1	-0.8	-0.6	-3.6	-3.4	.....	.....
4,500.....	-5.3	+0.2	-3.0	+2.6	-13.8	-1.1	-1.6	+0.6	-0.7	-0.4	-4.6	-3.6	.....	.....
5,000.....	-8.1	+0.2	-4.4	+4.0	-16.5	-1.0	.....	.....	-12.9	+0.4	-8.4	-4.9	.....	.....

RELATIVE HUMIDITY (%)													
Surface.....	70	+2	68	+2	75	+3	75	+1	72	+2	69	.....	.....
250.....	70	+2	68	+2	.....	.....	75	+2	72	+2	68	.....	.....
500.....	65	0	67	+1	74	+3	74	+3	71	+2	68	.....	.....
750.....	61	-2	65	-1	69	+2	72	+4	66	+1	61	.....	.....
1,000.....	59	-2	65	-1	65	+1	67	+3	65	-1	60	.....	.....
1,250.....	56	-2	60	0	63	+2	62	+2	62	-2	59	.....	.....
1,500.....	53	-3	56	+1	61	+2	57	0	60	-2	56	.....	.....
2,000.....	48	-4	53	+1	61	+4	50	-1	50	-2	54	.....	.....
2,500.....	46	-4	57	-1	62	-6	46	-3	51	-3	49	.....	.....
3,000.....	46	-3	54	-1	62	+7	44	-1	51	-1	47	.....	.....
3,500.....	45	-3	52	-1	60	-6	43	0	48	-2	44	.....	.....
4,000.....	45	-2	47	-6	57	-4	47	+5	44	-4	39	.....	.....
4,500.....	51	+6	52	0	56	-3	50	+10	43	-4	39	.....	.....
5,000.....	40	-5	15	-35	52	+1	.....	.....	42	-3	21	.....	.....

VAPOR PRESSURE (mb.)													
Surface.....	14.35	+0.57	14.39	+0.40	7.93	-0.17	17.96	+1.13	10.01	-3.18	12.90	.....	.....
250.....	14.21	+0.54	14.20	+0.42	.....	.....	17.43	+1.21	10.55	-0.06	11.91	.....	.....
500.....	12.56	-0.38	12.83	+0.47	7.72	-0.17	16.08	+1.35	9.43	+1.03	10.76	.....	.....
750.....	11.20	-0.23	11.78	+0.44	6.92	-0.19	14.66	+1.31	8.68	+0.19	9.66	.....	.....
1,000.....	10.30	-0.30	11.05	+0.57	6.28	-0.14	12.82	+1.11	7.94	+0.04	8.89	.....	.....
1,250.....	9.33	-0.30	10.34	+0.73	5.80	-0.05	11.14	+0.80	7.02	+0.04	8.02	.....	.....
1,500.....	8.31	-0.24	9.43	+0.74	5.28	-0.02	9.58	+0.49	6.29	-0.04	7.34	.....	.....
2,000.....	6.41	-0.06	7.44	+0.51	4.44	+0.10	7.06	+0.08	4.02	+0.02	4.92	.....	.....
2,500.....	5.03	+0.06	5.63	+0.18	3.71	+0.13	5.41	-0.17	3.53	+0.01	4.44	.....	.....
3,000.....	4.12	+0.18	4.49	+0.16	3.01	+0.15	4.33	-0.14	3.10	+0.12	3.38	.....	.....
3,500.....	3.36	+0.19	3.77	+0.27	2.32	+0.02	3.58	-0.09	2.41	+0.10	2.50	.....	.....
4,000.....	2.81	+0.05	2.83	-0.01	1.78	-0.11	3.07	+0.12	1.83	+0.06	1.89	.....	.....
4,500.....	2.01	+0.07	2.84	+0.42	1.23	-0.27	2.78	+0.32	1.51	+0.09	1.25	.....	.....
5,000.....	0.98	-0.53	.....	.....	0.60	-0.60	.....	.....	1.27	+0.10	0.67	.....	.....

\* Naval air station, Anacostia, D. C.

the East Gulf States northeastward to New England, with some sleet and the only snow of the month in the Middle Atlantic States. At the same time light, scattered snows occurred over most northern districts from the Great Lakes westward.

By the morning of the 6th a moderate barometric depression was central over Colorado, and light precipitation, mostly snow, had occurred from the upper Missouri Valley westward to Oregon and Washington. During the following 24 hours this depression moved to southeastern Iowa and precipitation extended into the central valleys, with some heavy rain in eastern Texas and considerable snow from the upper Lakes westward to Montana. During the following day this storm advanced to the southeastward, increasing greatly in severity as it crossed the upper Lakes where it was one of the most severe experienced in many years. Precipitation, mostly rain, extended into all districts from the Mississippi River eastward, heavy amounts occurring in a few localities, and some snow falling in the upper Lake region.

With the passage of this cyclone no important storm occurred until about the 12th, when general rains set in over a wide area from the west Gulf region northeastward to the Great Lakes and North Atlantic States, ex-

\* This paragraph will be discontinued with the issue for the current month.—Editor.

tending during the following day into the Middle Atlantic States, where, on the morning of the 14th, a well-developed barometric depression was present and heavy rains had occurred in portions of the Lake region and Ohio Valley.

At the same time a cyclone of considerable strength had moved from the north Pacific coast and was central over Colorado on the morning of the 14th, whence it moved to southern Wisconsin by the following morning and to Lake Superior by the morning of the 16th, but without important precipitation. As this was moving northeastward low-pressure was developing along the Atlantic coast and rain, heavy in many localities, had occurred over a wide belt from the West Gulf States northeastward to New England. During the following day the barometric depression became well-defined and moved northeastward off the coast of Maine and heavy rains extended into New England and the Canadian Maritime Provinces.

From the 17th onward no important cyclone entered the country until after the middle of the last decade, when low pressure moved from the far Southwest to the upper Lakes from about the 26th to 29th and widely extended precipitation occurred both to the westward and eastward of the low-pressure area as it advanced northeastward, the falls being light, however, except in portions of the Middle Gulf States. This was quickly followed by a rather important cyclone that developed over the eastern slope of the central Rocky Mountain region about the 28th and moved southward to Kansas during the following 24 hours and thence to the lower Lakes by the morning of the 30th. This caused a wide distribution of precipitation, particularly on the last day of the month from the Mississippi Valley eastward, with considerable snow over a narrow area from eastern Kansas to lower Michigan, and smaller amount over the upper Lakes.

Anticyclonic conditions prevailed during the first week over the Plateau region and again from about the 15th to about the 25th. Near the close the most important anticyclone and cold wave of the month had entered the northwestern districts and by the morning of the 31st had advanced into the upper Missouri Valley with atmospheric pressure above 31 inches, and decided cold had extended nearly to the coast of Texas, while the lowest temperatures of the month, 50° or slightly more below zero, were being experienced locally in the northern Rocky Mountain region.

The pressure for the month was mainly above normal and distinctly so along the northern border from Lake Superior to Montana and over the near-by Canadian Provinces. It was also distinctly higher than during the preceding month, except over a narrow area along the Atlantic coast and in central California.

Damaging windstorms were rather infrequent for the first winter month, and were confined largely to the area covered by the cyclone of the 7th and 8th in the middle Mississippi Valley and northeastward over the Great Lakes.

The prevailing wind directions were mainly from northerly points in the Missouri and upper Mississippi Valleys, in the Lake Superior district and New England; also in the Southern States from central Texas eastward. In the middle plains and thence eastward they were mainly from southerly points. Elsewhere they were variable.

#### TEMPERATURE

As stated previously December was a remarkably cold month over the northern districts from the Great Lakes

westward. No less than three distinct cold waves entered the upper Missouri Valley from the adjacent Canadian Provinces and overspread the districts to the southward and eastward with varying degrees of intensity.

The month opened with moderate cold existing over much of the country, ranging from about 10° below zero along the Canadian boundary from Lake Superior to northeastern Montana, to freezing in central Texas, with sharp falls of 20° to 40° within 24 hours over a wide area from southern Texas to the Great Lakes. The cold area reached the Atlantic coast during the day, and it continued cold in most districts from the Rocky Mountains eastward for several days.

The first cold wave in the Northwest entered that district on the 5th and by the morning of the 7th had advanced into the Great Plains with temperatures of zero or lower as far south as northwestern Kansas. This cold area advanced into the central valleys during the following 24 hours, with freezing weather to the Gulf coast and the line of zero temperatures extending to the southern limits of Kansas and Missouri. The cold wave had extended to the Atlantic coast by the morning of the 9th, bringing the lowest temperatures of the month in a number of States from the Great Plains eastward. This cold period was particularly severe in the South where minimum temperatures of 8° to 15° occurred at exposed points in the Gulf States and a temperature as low as 22° occurred in northern Florida.

A second important cold period over much of the country appeared over the upper Missouri Valley on the morning of the 13th, and, with some interruptions, finally overspread most districts to the southward and eastward during the following few days, passing off the Atlantic coast by the 17th. This cold wave also carried freezing temperatures nearly to the Gulf coast, and the coldest weather of the month was experienced in portions of the plateau and middle Pacific sections. A few States of the Southwest had the coldest weather of the month on the 18th and 19th when an extensive anticyclone covered the middle plateau.

The closing decade of the month had rather steady cold nearly throughout over much of the country, and by the morning of the 28th the third cold wave of the month appeared over the Canadian Northwest and by the following morning it had entered the Dakotas and near-by territory. By the end of the month the anticyclone had developed greatly, the barometric pressure had risen above 31 inches, and temperatures as low as zero had penetrated to the Panhandle region of Texas and into central Oklahoma, while readings from 30° to 50° below zero had occurred in the northern Rocky Mountains and thence eastward to Lake Superior and freezing weather had already reached south-central Texas. By the morning of January 1, 1928, the cold wave had reached the Gulf coast and north-central Florida with prospects of a further lowering. The lowest temperatures of the month occurred on the 31st in the far northwestern districts, and the lowest so far during the winter occurred during the early days of January over most districts to the southward and eastward, with severe damage to winter vegetation.

The highest temperatures of the month occurred on the 1st and 2d along the Atlantic coast and about the same time over most districts from the Rocky Mountains westward. Another warm spell occurred about the 12th and 13th over the central valleys and many eastern districts. Maximum temperatures went above 90° only in Texas, but they did not rise to 50° in portions of North Dakota and thence eastward to the Lake Superior district.

The month as a whole was the coldest of record for December over much of Montana, the Dakotas, and some near-by areas, the averages ranging from 15° to nearly 20° below normal, and the month was much colder than normal over nearly all other portions of the country from the Mississippi Valley westward save in certain of the coast districts of California, where, in a few instances, the month was slightly warmer than average.

Over the more eastern districts the average monthly temperatures were above normal, the excess increasing toward the Atlantic coast and New England, though even there the positive departures were mainly not large. In Canada the month was decidedly cold over western districts but moderately warm over the Maritime Provinces.

#### PRECIPITATION

The month was distinctly wet over most eastern districts and moderately dry in the West.

In the Southeastern States the monthly amounts were mainly well above normal, a few points having unusually heavy falls for December, though the distribution was satisfactory. Over Florida, however, the precipitation was generally less than normal, but sufficient as a rule to greatly benefit the trucking interests. Much replanting, however, was necessary, due to the dry weather preceding. Over the Plains States from Oklahoma to Nebraska and thence westward and northwestward to the Pacific there was mainly deficient precipitation, a few points in the north Pacific coast sections having the least precipitation of record for December. In portions of the far Northwest heavy rains during the first few days, in connection with rapid melting of the snow cover, due to warm weather, produced important floods in some of the mountain streams.

#### SNOWFALL

The amount of snow was generally less than is expected in December, save along the northern border from the

Great Lakes westward; there locally the fall was well above normal and some section had the heaviest individual snowstorms of record. Over the more eastern districts, however, there was mainly little snow and some stations in southern New England had the least of record for December, while others reported no snowfall during the entire month, a condition not heretofore observed.

Despite the absence of important snowfall over the country as a whole it was widely distributed and occurred in small quantities at least over most districts where it is usually expected.

Some heavy falls occurred in the upper Mississippi Valley on the 6th-7th in connection with the severe storm on those dates over the Great Lakes, and some heavy local falls occurred in the Dakotas and Minnesota on the 14th and 15th. In Buffalo, N. Y., rather unusual conditions as to snowfall existed on the 17th and 18th. On the 17th the heaviest snow of the year was recorded at the Weather Bureau office, nearly 13 inches, while on the following day only a trace was recorded at that office, while in some outlying suburbs the snow fell to depths of 2 to 4 feet, the greatest of record, causing almost complete tie-ups in local traffic.

Snow was generally deficient in the central and southern mountain districts and the accumulated pack at the end of the month was usually less than normal.

#### RELATIVE HUMIDITY

Despite a marked excess of precipitation over most portions of the South Atlantic and Gulf Coast States there was a general, and, in some cases, extensive deficiency in the average relative humidity. There were likewise important deficiencies in the middle and southern Plains and over the far Northwest, which may be attributed to the general lack of precipitation. Over most other districts there were general excesses, these being large in the far Southwest and over northern districts from the Rocky Mountains to the Great Lakes.

#### SEVERE LOCAL STORMS, DECEMBER, 1927

The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.

Place	Date	Time	Width of path	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Virginia (southeastern)	4		Yards			High winds	Considerable damage by high water; some sections near Norfolk inundated.	Official, U. S. Weather Bureau.
Havre, Mont.	4-5					Wind and snow	A number of people and livestock frozen to death; minor property damage.	Do.
Hearne, Tex., and vicinity	6	P. m.		1		Wind and rain	Two homes wrecked, others blown from foundations; roofs torn off and cotton sheds demolished.	Dallas Morning News (Tex.)
Illinois, Indiana, Iowa, Minnesota, Missouri, Ohio, and Wisconsin	6-8					Wind and snow	Heavy damage to wires, trees, and poles; transportation delayed; many minor accidents and several deaths reported; much suffering from cold.	Official, U. S. Weather Bureau.
Tunnell Springs, Ala. (near)	7			1		Tornadic wind	School building and several homes demolished; trees uprooted.	Courier (Evansville, Ind.).
Cheesman Lake, Colo.	8					Wind	Many trees broken; roofs blown off.	Official, U. S. Weather Bureau.
Buffalo, N. Y., and vicinity	8			5	700,000	Severe wind	Lake steamers, small craft, amusement beaches, and lake shore property damaged.	Do.
Parkersburg, W. Va.	8	A. m.				do.	Overhead wires considerably damaged.	Do.
Mount Vernon (near) to Oakland City, Ind.	13				50,000	Tornadic wind	Trees, wires, crops, and buildings damaged.	Do.
New York (northern)	16					Glaze and wind	Great amount of damage to telephone, telegraph, and power lines; trees broken; transportation delayed.	Do.
South Dakota (western)	29-30					Wind and snow	Highways impassable; stock suffers greatly; trains delayed.	Do.
Illinois and Missouri	30-31					do.	Trains delayed; highways obstructed; car service hampered; 2 railway accidents in Illinois.	Do.

## STORMS AND WEATHER WARNINGS

## WASHINGTON FORECAST DISTRICT

Storm warnings were ordered on the morning of the 2d from Delaware Breakwater to Boston and during the day were extended northward to Eastport. On the 3d warnings were displayed between Norfolk and Charleston and on the morning of the 4th extended northward to Boston, and that evening northward to Eastport. On the 5th warnings were changed to northwest between Boston and Nantucket. On the 7th southwest warnings were hoisted between Cape Hatteras and Eastport, and continued on the following day north of Delaware Breakwater.

Warnings were again ordered on the afternoon of the 15th between Delaware Breakwater and Eastport and continued on the 16th north of Nantucket, and warnings were ordered between Delaware Breakwater and Wilmington. The morning advices of the 19th to shipping for strong west and northwest winds off the middle and North Atlantic coasts, possibly reaching gale force at times, were supplemented on the evening of that date by the issuance of storm warnings between Delaware Breakwater and Portland, Me., and on the morning of the 20th by storm warnings north of Portland to Eastport. Warnings were again displayed on the 29th between Norfolk and Eastport, but winds did not reach the force expected. On the morning of the 31st southwest warnings were disseminated from Eastport to Jacksonville and were continued on the following day north of Sandy Hook.

The conditions experienced by Colonel Lindbergh for his nonstop flight from Washington, D. C., to Mexico City, December 13-14, were characterized by him as "exactly as predicted."

Small-craft warnings were displayed on the 14th for the middle and North Atlantic coasts, on the 15th for the East Gulf coast, on the 16th and 24th on the middle and South Atlantic coasts, and on the 28th for the East Gulf coast.

Frost warnings were issued for the East Gulf States on the 3d and on the 5th for the South Atlantic and portions of the East Gulf States. Cold-wave warnings were ordered on the 7th for portions of Mississippi, Kentucky, and Tennessee, and on the 8th freezing temperatures were indicated for the South Atlantic and East Gulf coasts, and frosts in Florida. Frosts also were indicated for Florida on the 9th and 17th. Warnings for freezing temperatures were disseminated on the 19th for the South Atlantic and East Gulf States except central and southern Florida. On the following morning these warnings were repeated and extended to include central Florida. Frosts were again indicated for northwest Florida and Alabama.

On the morning of the 30th cold-wave warnings were ordered for portions of Tennessee and Kentucky and on the evening of that date for Alabama, Mississippi, extreme northwest Florida, West Virginia, western Pennsylvania, and Kentucky and Tennessee. On the morning of the 31st cold-wave warnings were ordered for the District of Columbia, the west portions of Maryland, Virginia, and North Carolina.—*R. H. Weightman.*

## CHICAGO FORECAST DISTRICT

The outstanding features of the weather were the severe storm of the 6th-8th and the month's coldness in the northwestern portion of the district. The storm

in question was one of the severest in this forecast district in recent years, while the month was either the absolute coldest or one of the coldest Decembers in more than half a century in the Dakotas and Minnesota. At Bismarck, N. Dak., the daily minimum temperature was below zero every day, but three.

The weather conditions were active during the first 15 days and the last 5 days of the month, with a very quiet period from the 16th to the 20th.

*Storm warnings for the Great Lakes.*—Conditions required the issuance of either small-craft or storm warnings for the Great Lakes on five occasions before the season came to a close on the 15th. After the 15th two advisory warnings were issued for shipping on Lake Michigan.

As indicated in the foregoing, the storm of the 6th-8th was of great severity. Popularly it was called a blizzard, and doubtless this characterization fits scientific usage in most respects. The genesis of the storm was somewhat unusual. It appeared to form over the northern Rocky Mountain region on the night of the 4th-5th, whence it moved slowly southeastward during the following 36 hours to the Texas Panhandle with a steady development. From Texas a recurve to the northeastward was begun. By the time the center had reached the middle Mississippi Valley on the morning of the 7th the storm had acquired considerable intensity. However, there was a further marked development during the following 24 hours. Whole gale or even hurricane force was reached over a wide area during this latter 24-hour period. At Buffalo, N. Y., the hourly maximum velocity was between 80 and 86 miles for 12 consecutive hours. At that port the storm caused damage approximating \$700,000. About 30 lake steamers dragged anchors and some went aground, while others were considerably damaged by crashing into each other. A number of small craft were wrecked. At other points on the Great Lakes vessels underwent a severe battering and a number were driven aground. No loss of life is known to have occurred, owing to the daring rescue work by Coast Guard men and others.

The warnings issued for this storm were especially timely. On the 7th, 12 hours or so before the storm became of great intensity, the regular forecasts made mention of the great severity expected and shipping was advised to exercise the utmost caution.

*Ice blockade.*—An ice blockade similar in character to that which occurred last year began near the "Soo" about the 10th. The blockade was broken temporarily a few times, but in the end it became necessary for 23 boats to winter in the ice, 16 of them being on the American side of the river and 7 on the Canadian side.

*Cold waves.*—Seven occasions during the month required the issuance of cold-wave warnings. Some of these warnings were for limited areas, but those issued on the 5th-7th, 14th-15th, and 29th-31st were more or less general in scope. In a few cases cold waves occurred over small areas without previous warning. Both the cold wave that followed the severe storm described in the foregoing and the one at the close of the month were severe. At Cairo, Ill., the temperature fell to 2° below zero on the morning of January 1, 1928. The accompanying area of high barometer was of great magnitude, with a sea-level pressure of 31.22 inches at Miles City, Mont., at 7 p. m. December 31.

*Stock warnings.*—Warnings for stock were issued on the 6th and 14th for Kansas and Nebraska and on the 28th for South Dakota and Nebraska.—*C. A. Donnel.*

## NEW ORLEANS FORECAST DISTRICT

Three general cold waves occurred—on the 7th–8th, 15th–16th, and December 30–January 1. They were preceded by crescent-shaped troughs of low pressure with the southern end of the trough swinging eastward more rapidly than the northern end, resulting in cold waves of wide sweep, with rapid movement over the extreme southern sections.

No cold wave occurred without timely warning, and the cold-wave warnings issued were verified except that the required minimum temperatures were not reached at El Paso and Brownsville, Tex., on the 8th. Southeastern Louisiana was excepted in the warnings for the cold wave of the 15th–16th and no cold wave occurred in that portion of the State in this instance. Warning for Oklahoma was issued on the morning of the 10th for a cold wave of limited extent, which occurred in that State the following night.

Livestock interests were given the cold-wave warnings, and livestock and special warnings were also issued on the morning of the 17th for the northern portion of the district for low temperatures that occurred the following morning.

Frost or temperature warnings for the more southern sections were issued on the 1st, 2d, 3d, 4th, 8th, 9th, 16th, 17th, 18th, 19th, and 20th. The warning of the 8th advised the cutting of sugar cane, and temperatures of 23° to 26° occurred in the sugar region of Louisiana the next morning.

The cold waves were attended by northerly winds, requiring either small-craft or storm warnings. Northwest storm warnings for the Texas coast and small-craft warnings for the Louisiana coast were issued on the morning of the 7th; northwest storm warnings for the Texas coast and small-craft warnings for Morgan City, La., on the morning of the 15th, with small-craft warnings for the remainder of the Louisiana coast at 12:20 p. m. of the 15th; and northwest storm warnings for the coast from Morgan City, La., to Brownsville, Tex., at 8 p. m. of the 30th, with extension along the remainder of the Louisiana coast the next morning. Small-craft warnings were issued also by local officials as follows: At Galveston, Tex., in the afternoon of the 6th, and at Corpus Christi, Tex., in the afternoons of the 8th, 14th, 17th, and 30th. No storm occurred without warning.

"Norther" warnings for shipping at Tampico, Mexico, were issued on the 7th, 15th, 18th, and 30th, and strong northerly winds or gales occurred as indicated.—R. A. Dyke.

## DENVER FORECAST DISTRICT

Mean temperatures were considerably below normal throughout the district, especially in the northern and central portions. In Montana the deficiencies ranged from 11° to 19° and at several stations in that State this was the coldest December experienced in more than 40 years. The mean temperature of 1.2° at Havre was the lowest for December since the record began, in 1880. In general, precipitation was above normal, although a few stations reported deficiencies.

The month was characterized by a succession of high-pressure areas over Montana and the Canadian territory to the northward. The most noteworthy of these highs appeared north of Montana on the 27th, attained marked intensity by the morning of the 30th, and had overspread the entire Rocky Mountain and Great

Plains regions by the morning of the 31st. A crest reading of 31.22 inches at Miles City was reached the evening of the 31st. Most of these northern highs were skirted by troughlike low-pressure systems extending from British Columbia southeastward to Colorado and thence eastward or northeastward across the Missouri Valley.

Numerous centers of low pressure moved more or less rapidly along this path, resulting in radical temperature changes in Montana, Wyoming, and Colorado, and necessitating the issuing of many cold-wave warnings as follows: On the 5th, 6th, 7th, 9th, 12th, 13th, 14th, 15th, 16th, 27th, 28th, 29th, and 30th.

Most of these warnings were fully verified; the rest were partially verified. On one or two occasions the cold waves overspread some territory not included in the warnings. Warnings of frosts and freezing temperatures for south central and southeastern Arizona were issued frequently throughout the month; most of them were successful. Warnings of fresh to strong winds, for the benefit of aviators, and, when snow and low temperatures were expected also, for the benefit of stockmen, were issued as follows: On the 3d, 4th, 5th, 6th, 11th, 14th, 15th, 16th, 17th, and 19th.—E. B. Gittings.

## SAN FRANCISCO FORECAST DISTRICT

A high-pressure system which moved inland early in the month developed sufficient strength, concurrently with a moderate depression over and to the west of Baja California, to bring about "Santa Ana" winds in southern California on the 4th and create a fire hazard of unusual acuteness for the winter season. Several brush and timber fires occurred in the Los Angeles area. These winds were definitely indicated in the district forecast of December 3.

On the 6th a southward movement of Arctic high pressure brought unseasonably cold weather to the Plateau and intermountain regions, advance warning of which was given. A second very marked period of cold over the same region was ushered in on the 14th, sub-zero temperatures being recorded in eastern Washington. Temperatures below normal were forecast, but cold-wave warnings were not issued. A third period of very unusual cold and the most extreme of all began on the 28th. It covered more territory than the others, extending west of the Cascade Mountains and persisting into the opening days of the next month. Its advent was plainly indicated on the weather charts, and advance notice was given.

Storm or small-craft warnings were displayed on nine occasions on the north coast and twice on the California coast above San Francisco. Two of these warnings were apparently uncalled for. A third, which was followed by only fresh winds at shore stations, may have been justified by the occurrence of moderate gales at sea.

Special snow warnings were sent to recipients in western Washington on the 31st and well verified. The regular route forecasts for air-mail lines were issued as usual, especial importance attending them due to the prevalence of inclement weather. The pilot on the Fresno-Los Angeles route met with disaster on December 25. He was prevented by rain and wind from landing at Bakersfield on his way south, and, turning back in the hope of finding better conditions at his starting point, was overtaken by darkness and forced to come down by parachute, leaving his plane to crash.—T. R. Reed.

## RIVERS AND FLOODS

By H. C. FRANKENFIELD

*Atlantic drainage.*—During the evening of December 7 and the morning of December 8 moderately heavy rains fell upon a substantial snow cover in New England and interior New York. As the soil was saturated, the runoff was greater than usual, and either bankful or flood stages resulted in most streams. Over the Winooski Valley of Vermont the river between banks was full and there were fears of a repetition of the November flood. Reassuring advices were issued and the rise passed off without serious consequences. A temporary bridge at Waterbury, Vt., was carried away, and in the towns along the river there was considerable flooding of roads, basements, and cellars.

The Connecticut River was in moderate flood above Bellows Falls, Vt., on December 8, and at Hartford, Conn., two days later. Advisory warnings were issued, and the resulting damage was small. At Hartford, Conn., there was much alarm felt, but nothing occurred beyond the flooding of the meadow districts and a few houses and roads.

Warnings were issued on December 8 for the lower Hudson River, and on the following day the river reached the forecast stage of 13 feet at Albany, and a stage of 17.3 feet, 2.3 feet above the flood stage, at Troy, N. Y. No material damage resulted, and savings reported amounted to between \$600 and \$800. Heavy rains on December 2, 3, and 4 over the Carolinas were followed by moderate floods in nearly all rivers. No losses were reported in North Carolina. The rises were very helpful to logging interests, and savings through warnings were reported at \$10,000. Additional heavy rains from December 14 to 16 caused secondary rises over the Santee River system of South Carolina, for which warnings were also issued. Some losses in livestock, probably amounting to \$1,000, were reported in the swamps about the confluences of the Wateree, Congaree, and Santee Rivers, but other livestock to the value of \$10,000 were driven to higher ground upon receipt of the warnings.

*East Gulf drainage.*—The rains from December 14 to 16 were followed by moderate floods in the Tombigbee system of Alabama and locally over the middle reaches of the Pearl River of Mississippi, and warnings were issued promptly. The Black Warrior and Tombigbee floods were somewhat earlier than usual, and losses were comparatively large for that section, amounting to about \$79,400, of which \$10,000 was in matured crops. Reports received indicate that property to the value of \$91,500 was saved through the warnings. In some localities the flood was of great value to logging interests, as a great quantity of logs was floated out from swamp lands.

The Pearl River did not quite reach the flood stage of 20 feet at Jackson, Miss., during the first rise, but with the aid of additional heavy rains on December 28 and 29 the river passed the flood stage on the latter date and continued to rise slowly to a crest of 24.2 feet on January 7, 1928. The river was above the flood stage at Jackson from December 29, 1927, to January 12, 1928. During this rise the West Pearl River at Pearl River, La., also reached the flood stage. No losses resulted from these floods other than a little due to temporary suspension of business in some localities.

*Great Lakes drainage.*—Rains of 2 to 4 inches during the last three or four days of November and on December 1 resulted in general floods in the Maumee and

Sandusky Rivers of Ohio, for which the usual warnings were issued. The Maumee River at Fort Wayne, Ind., reached a crest of 18.2 feet, 3.2 feet above the flood stage, on December 3, while the tributary St. Joseph River exceeded the flood stage of 10 feet by 4 feet at Montpelier, Ohio, on December 1. Additional heavy rains on December 12 and 13 caused a second flood of about the same proportions from December 14 to 18. Damage was inconsequential. There were also two flood crests in the Sandusky River of Ohio coincident with the Maumee crests, and here again there was little or no damage.

An ice jam at the new Fulton Street bridge in Grand Rapids, Mich., caused a 5-foot rise in the Grand River from December 18 to 19. The highest stage was 11.7 feet, or 0.7 foot above the flood stage. During this rise the gauge at the city filtration plant, about 1¼ miles upstream, showed a steady fall in the river.

At Portland, Mich., there was a local ice jam in the Grand River on December 12, although the river did not reach the flood stage. Neither at Portland nor Grand Rapids was there any damage of consequence.

*Ohio Valley.*—Frequent and sometimes moderately heavy rains over the Allegheny, Monongahela, and upper Ohio River basins during the last half of November saturated the soil and increased the stream flow to such an extent that the main rivers were nearly bankful by the end of the month. On the last day of the month nearly 2 inches of rain fell over the upper Allegheny Basin and the river quickly rose to flood stage. To the southward the rains were light. The crest of the rise reached Pittsburgh, Pa., on December 2 with a stage of 23 feet, 2 feet below the flood stage. The crest passed Shawneetown, Ill., on December 11 but was lost below that point in the continued rise caused by later rains.

The total loss due to this flood was about \$2,000.

During early December there was sufficient rain to maintain a rather heavy flow in the rivers of the Ohio system, and from December 8 to 20 there were only two or three days without rain, with the heaviest fall from December 13 to 16, and on December 14 an up-river flood set in, except in the Monongahela River, that carried through to the mouth of the Ohio River, although only in moderate form below the mouth of the Great Kanawha River.

Warnings for the Pittsburgh district were issued on December 13 and again on the morning of December 14, when a stage between 29 and 30 feet, or 5 feet above the flood stage, was forecast for Pittsburgh by 6 p. m. of that day, later changed to 30 to 31 feet by 8 p. m. A crest of 30.4 feet was reached at 9 p. m. The forecast of 42 to 43 feet at Wheeling, W. Va., on December 15 was later changed to not to exceed 42 feet, and the crest was 40.8 feet, or 4.8 feet above the flood stage, at 3 p. m., December 15.

Losses in the Pittsburgh district due to the flood were estimated at \$25,000, while the value of property saved by the warnings was reported to have been \$100,000. Many expressions of commendation regarding the warning service were received. The police department and the newspapers of Pittsburgh assisted greatly in distributing information of the rapid approach of the flood.

From Wheeling, W. Va., to the mouth of the Kanawha River the crests averaged from 4 to 5 feet above the flood stages. Excellent warnings were issued from the district center at Parkersburg, W. Va., and there was ample time for all precautionary measures. There were the

usual annoyance and extra labor in the cities, but practically no loss; but farmers lost hay, corn, and corn fodder to the value of perhaps \$50,000.

In the Cincinnati, Ohio, and Louisville, Ky., districts rivers only approximated the flood stages. The necessary warnings were issued and there was no damage worthy of special mention.

In the Evansville, Ind., and Cairo, Ill., districts the crest stages were from 2½ to 5 feet above the flood stages, which, however, were absent above the mouth of the Cumberland River. The only losses reported were \$5,000 in crops in the Shawneetown, Ill., section, with savings of about \$10,000 in stock and corn. The crest of the flood passed Cairo, Ill., on December 23 and 24 with a stage of 38.2 feet, or 6.8 feet below the flood stage.

The Ohio and Indiana tributaries of the Ohio River were also in flood and contributed quite materially to the main flood. Stages several feet above flood stage were reached in the Muskingum, Tuscarawas, Walhonding, and Scioto Rivers, and warnings were issued when possible. Losses as reported aggregated \$36,500, of which \$10,000 was in crops.

The floods in the Wabash system were of the same general character. While they were very well forecast, the losses were very heavy on account of the large quantities of corn that had not dried sufficiently for husking, the reported value of which was \$201,200. Other losses reported amounted to \$37,500, making a total of \$238,700. In the city of Terre Haute, Ind., some streets and houses were flooded by the rise during the first week of the month.

**Mississippi drainage.**—Under the influence of occasional rains in the latter days of November and the first 10 days of December, a flood that began in the Illinois River during the last two days of November continued throughout the month of December, and the crest stages were several feet above the flood stages. There were three rises in the upper river, merging into a single rise in the alluvial river. Timely warnings were issued and the only trouble caused was the retardation of flood protection work below Peru, Ill.

The heavy rains of November 30 and December 1 caused moderate and harmless floods in the Bourbeuse and Meramec Rivers of Missouri, and there was a second flood of a similar nature on December 16. The usual warnings were issued.

In the Black River of Missouri and Arkansas there was a greater flood during the mid-month period, and warnings began on December 13, the first day of heavy rains. The resulting damage was largely to lumber in the vicinity of Poplar Bluff, Mo.

The rains from December 12 to 14 were followed by a moderate flood in the White River of Arkansas. Over the upper portion of the river the crest stages were far above the flood stages, while below they were much more moderate, and at Clarendon, Ark., the flood stage was not reached. Moderate flood stages were also recorded in the Arkansas River from Dardanelle to Morrilton, and at Yancopin, Ark. Apparently there was very little loss or damage.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE					
Connecticut:	Feet			Feet	1927
White River Junction, Vt.	15	8	9	16.7	Dec. 8.
Hartford, Conn.	16	10	11	17.0	Dec. 10.
Hudson: Albany, N. Y.	12	9	9	13.0	Dec. 9.
Unadilla: New Berlin, N. Y.	8			8.2	Dec. 8.
Roanoke: Weldon, N. C.	30	5	10	37.6	Dec. 6.
Tar:					
Tarboro, N. C.	18	7	10	19.8	Dec. 9.
Greenville, N. C.	14	7	12	15.9	Dec. 10.
Neuse:					
Neuse, N. C.	15	5	7	15.7	Dec. 6.
		17	17	15.1	Dec. 17.
Smithfield, N. C.	14	5	9	18.0	Dec. 6.
		18	19	14.8	Dec. 18.
Cape Fear:					
Fayetteville, N. C.	35	5	7	39.3	Dec. 6.
Elizabethtown, N. C.	22	5	10	30.2	Dec. 7.
		18	20	24.9	Dec. 19.
Peedee:					
Cheraw, S. C.	27	17	18	28.0	Dec. 18.
Mare Bluff, S. C.	17	7	12	18.9	Dec. 9-10.
		19	22	17.8	Dec. 22.
Santee: Ferguson, S. C.	12	8	28	13.7	Dec. 10, 23.
Congaree: Columbia, S. C.	15	3	4	15.6	Dec. 4.
Broad: Blains, S. C.	15	4	5	16.9	Dec. 5.
		16	17	15.0	Dec. 16-17.
Saluda:					
Pelzer, S. C.	7	16	17	7.8	Dec. 16.
Chappells, S. C.	14	4	5	15.1	Dec. 5.
		16	18	13.9	Dec. 17.
EAST GULF DRAINAGE					
Tombigbee: Lock No. 4, Demopolis, Ala.	39	19	24	44.0	Dec. 21.
Black Warrior: Lock No. 10, Tuscaloosa, Ala.	46	16	18	54.6	Dec. 17.
Pearl: Jackson, Miss.	20	20	Jan. 12	24.2	1928 Jan. 7.
GREAT LAKES DRAINAGE					
Maumee: Fort Wayne, Ind.	15	1	5	18.2	1927 Dec. 3.
		14	18	17.8	Dec. 15.
St. Joseph: Montpelier, Ohio	10	(?)		14.0	Dec. 1.
				13.2	Dec. 15.
Sandusky:					
Upper Sandusky, Ohio	13	1	2	15.5	Dec. 2.
		14	14	16.5	Dec. 14.
Tiffin, Ohio	7	16	16	7.2	Dec. 16.
Grand: Grand Rapids, Mich.	11	19	20	11.7	Dec. 19.
MISSISSIPPI DRAINAGE					
Allegheny:					
Warren, Pa.	12	1	2	13.2	Dec. 1.
Franklin, Pa.	15	1	2	17.2	Do.
Parkers Landing, Pa.	18	1	1	18.2	Do.
Lock No. 5, Freeport, Pa.	24	1	3	27.7	Dec. 2.
		14	17	30.7	Dec. 14.
Lock No. 4, Natrona, Pa.	24	2	2	26.4	Dec. 2.
		14	15	28.3	Dec. 14.
Lock No. 3, Springdale, Pa.	27	14	14	28.5	Do.
Monongahela:					
Lock No. 7, Greensboro, Pa.	30	14	14	30.4	Do.
Lock No. 4, Pa.	31	14	14	31.4	Do.
Ohio:					
Pittsburgh, Pa.	25	14	15	20.4	Do.
Lock No. 2, Coraopolis, Pa.	26	14	15	27.8	Do.
Beaver Dam, Pa.	30	14	17	37.9	Dec. 15.
Dam No. 12, near Wheeling, W. Va.	36	15	16	37.7	Do.
St. Marys, W. Va.	38	16	17	38.7	Dec. 16.
Marietta, Ohio	33	15	19	40.7	Dec. 17.
Parkersburg, W. Va.	36	16	19	41.9	Do.
Dam No. 19, Tallman, W. Va.	39	16	19	42.7	Do.
Dam No. 22, Ravenswood, W. Va.	42	16	19	46.1	Do.
Point Pleasant, W. Va.	40	17	20	45.3	Dec. 18.
Dam No. 25, near Point Pleasant, W. Va.	40	16	20	46.9	Dec. 19.
Dam No. 29, Normal, Ky.	50	19	20	51.0	Do.
Portsmouth, Ohio	50	19	20	51.0	Do.
Dam No. 33, Maysville, Ky.	48	20	20	48.2	Dec. 20.
Dam No. 44, Leavenworth, Ind.	48	21	23	48.4	Dec. 22.
Dam No. 45, Addison, Ky.	40	20	24	42.5	Dec. 22-23.
Cloverport, Ky.	40	21	23	40.6	Do.
Evansville, Ind.	35	19	27	38.7	Dec. 24.
Dam No. 48, Cypress, Ind.	35	20	26	37.6	Do.
Mount Vernon, Ind.	35	20	27	38.5	Dec. 25.
Shawneetown, Ill.	35	17	28	40.1	Do.

<sup>1</sup> Estimated.

<sup>2</sup> Continued from last month.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI DRAINAGE—continued					
	Feet			Feet	1927
Beaver: Beaver Falls, Pa.	11	14	17	13.1	Dec. 14.
Shenango: Sharon, Pa.	9	1	3	12.3	Dec. 2.
		14	17	10.8	Dec. 14.
Muskingum:					
McConnelsville, Ohio.	22	15	19	24.3	Dec. 17.
Beverly, Ohio.	25	16	16	25.1	Dec. 16.
Marietta, Ohio.	28	15	19	34.5	Dec. 17.
Tuscarawas:					
Gnadenhutten, Ohio.	9	(?)	5	14.2	Dec. 2-3.
		13	20	15.4	Dec. 17.
Coshocton, Ohio.	8	1	4	14.7	Dec. 2.
		14	19	14.4	Dec. 16.
Walhonding: Walhonding, Ohio.	8		3	14.1	Dec. 1.
Scioto:					
Larue, Ohio.	11	1	2	14.1	Do.
		14	15	14.4	Dec. 14.
Prospect, Ohio.	10	1	3	12.9	Dec. 2.
		15	17	12.7	Dec. 15.
Bellpoint, Ohio.	9	1	1	9.7	Dec. 1.
Circleville, Ohio.	10	2	3	13.5	Dec. 3.
		14	17	14.0	Dec. 15.
Chillicothe, Ohio.	16	3	4	17.6	Dec. 3.
		15	17	18.1	Dec. 16.
Oiantangy: Delaware, Ohio.	9		1	12.0	Dec. 1.
Little Miami: Kings Mills, Ohio.	17	14	14	20.7	Dec. 14.
Wabash:					
Lafayette, Ind.	11	(?)	10	21.9	Dec. 2.
		14	18	18.8	Dec. 16.
Covington, Ind.	16	(?)	20	25.0	Dec. 4.
Terre Haute, Ind.	16	2	21	21.2	Dec. 5.
Vincennes, Ind.	14	6	25	19.1	Dec. 9.
Mount Carmel, Ill.	16	3	25	22.1	Dec. 9, 17.
Tippecanoe: Norway, Ind.	6	(?)	26	6.5	Dec. 1, 2, 7,
		29	29	6.1	14, 16, 29.
White: Decker, Ind.	18	5	10	19.3	Dec. 8-9.
		15	23	20.0	Dec. 21-22.
White, East Fork:					
Seymour, Ind.	10	1	3	12.5	Dec. 2.
		15	15	11.5	Dec. 15.
Williams, Ind.	10	18	18	10.5	Dec. 18.
Shoals, Ind.	20	6	6	20.4	Dec. 6.
		18	20	21.2	Dec. 19.
White, West Fork:					
Elliston, Ind.	19	3	4	19.7	Dec. 4.
		15	17	21.0	Dec. 17.
Edwardsport, Ind.	15	2	6	17.0	Dec. 5.
		15	20	17.5	Dec. 18-19.
Rk: Fayetteville, Tenn.	14	31	31	16.3	Dec. 31.
Illinois:					
Morris, Ill.	13	(?)	5	14.7	Dec. 1.
		8	17	15.4	Dec. 15-16.
Peru, Ill.	14	(?)	(?)	20.0	Dec. 18-19.
Henry, Ill.	10	(?)	(?)	14.4	Dec. 17-18.
Peoria, Ill.	18	2	(?)	20.9	Dec. 18-20.
Havana, Ill.	14	1	(?)	18.1	Dec. 19.
Beardstown, Ill.	14	2	(?)	19.3	Dec. 16-18.
Pearl, Ill.	12	4	(?)	15.8	Dec. 20.
Meramec:					
Pacific, Mo.	11	1	4	15.5	Dec. 2.
Valley Park, Mo.	14	1	4	16.8	Do.
		15	17	16.9	Dec. 16.
Bourbon: Union, Mo.	12	2	3	15.9	Dec. 3.
St. Francis: St. Francis, Ark.	17	17	28	26.1	Dec. 19.
Arkansas:					
Dardanelle, Ark.	20	14	14	23.8	Dec. 14.
Morrilton, Ark.	20	14	14	20.0	Do.
Yancopin, Ark.	29	17	17	22.1	Dec. 17.
Petit Jean: Danville, Ark.	20	15	17	22.7	Dec. 16.
White:					
Calico Rock, Ark.	18	14	17	36.6	Dec. 14.
Batesville, Ark.	23	14	18	37.6	Dec. 15.
Newport, Ark.	26	16	21	29.7	Dec. 18.
Georgetown, Ark.	22	19	29	25.4	Dec. 22.
DeValls Bluff, Ark.	24	22	29	25.7	Dec. 24.
Buffalo: Gilbert, Ark.	30	14	14	30.0	Dec. 14.
Black:					
Leeper, Mo.	11	14	14	15.5	Do.
Williamsville, Mo.	11	14	15	16.0	Do.
Poplar Bluff, Mo.	14	14	17	18.1	Dec. 15.
Corning, Ark.	11	16	28	15.1	Dec. 19.
		31	31	11.0	Dec. 31.
Black Rock, Ark.	14	14	(?)	25.3	Dec. 15.
WEST GULF DRAINAGE					
Trinity: Trinidad, Tex.	28	10	24	28.5	Dec. 21-22.
PACIFIC DRAINAGE					
Columbia: Vancouver, Wash.	15	(?)	2	15.3	Nov. 29.
Willamette:					
Harrisburg, Oreg.	7	(?)	4		
Portland, Oreg.	15	(?)	3	17.5	Do.
Willamette, Coast Fork: Saginaw, Oreg.	5	13	15	5.3	Dec. 14-15.
		30	(?)	5.4	Dec. 31.

\* Continued from last month.

\* Continued at end of month.

## MEAN LAKE LEVELS DURING DECEMBER, 1927

By UNITED STATES LAKE SURVEY

[Detroit, Mich., January 3, 1928]

The following data are reported in the Notice to Mariners of the above date:

Data	Lakes <sup>1</sup>			
	Superior	Michigan and Huron	Erie	Ontario
Mean level during December, 1927:				
Above mean sea level at New York.....	Feet 602.39	Feet 578.82	Feet 571.51	Feet 245.65
Above or below—				
Mean stage of November, 1927.....	-0.15	-0.09	+0.40	+0.30
Mean stage of December, 1926.....	+0.75	+0.57	+0.05	+0.25
Average stage for December, last 10 years.....	+0.52	-0.56	-0.02	+0.45
Highest recorded December stage.....	-0.74	-3.76	-2.02	-1.96
Lowest recorded December stage.....	+2.14	+1.28	+1.12	+2.22
Average departure (since 1860) of the December level from the November level.....	-0.27	-0.22	-0.08	-0.09

<sup>1</sup> Lake St. Clair's level: In December, 1927, 574.13 feet.

## EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, DECEMBER, 1927

By J. B. KINCER

*General summary.*—The outstanding favorable feature of the weather during the first decade of December was the effective relief of the droughty conditions in the southeastern States. Generous to heavy rains there bountifully supplied the soil with needed moisture, which, together with the generally mild temperatures, brought a marked improvement to the agricultural situation. In the trans-Mississippi States cool weather brought frost nearly to the Gulf coast with more or less damage to tender vegetation. Early in the period farm work made good advance in the more eastern States and upper Ohio Valley, but toward its close frequent precipitation and severe wintry conditions over large areas of the country westward to the Rocky Mountains were unfavorable, with little farm work accomplished.

During the second decade frequent rains, followed by cold, windy, disagreeable weather in most sections east of the Mississippi River, made conditions generally unfavorable for outside operations and very little activity on farms was reported. Over the Central and Northern States to the westward the continued abnormally low temperatures and rather severe snowstorms in northern districts were also unfavorable for agricultural interests.

During the last decade in the more northern districts east of the Mississippi River generally ample sunshine, absence of appreciable precipitation, and the frozen ground enabled corn husking to make excellent advance, with much progress reported in other sections to the westward. The lack of adequate snow cover over Central States caused some apprehension during the cold weather. Much hog killing was done in southern areas. In a large part of the Northeast there was very little farm activity, but from the Great Lakes westward there was a revival of outdoor operations, attending the reaction to more favorable weather.

*Small grains.*—At the beginning of the month grain fields were mostly protected by a snow cover in the northeast as far south as the Potomac Valley, in the Lake region, and in most sections between that region and the Rocky Mountains; the latter part of the first

decade, however, found most of the Winter Wheat Belt bare of snow with high winds in the central-northern portion of the belt contributing to the removal of the cover. Some heaving was reported in sections of the Lake region and cool weather checked growth in Southern States, but advance was satisfactory in most areas, except that continued dry weather over considerable sections of the southern Great Plains was detrimental.

During the second decade further unseasonably cold weather occurred over the Winter Wheat Belt, but in all except the more western portion the unusually favorable growing conditions during the fall had permitted the wheat plants to establish a good root system. In the more western portions of the belt the persistent drought and low temperatures were decidedly unfavorable.

During the last decade continued dryness in the southwestern Great Plains was unfavorable for winter wheat and the absence of adequate snow cover caused considerable apprehension in the upper Ohio Valley, but grains in general continued in mostly satisfactory condition.

**Corn and cotton.**—Husking corn made good advance quite generally the first part of the first decade rather generally west of the Mississippi River and fairly good progress was made in eastern portions. During the second decade husking and cribbing was delayed or entirely suspended over the interior valleys because of stormy, wintry conditions. Excellent weather for husking prevailed during the last decade in those areas where this work had not been completed. Weather conditions during the first decade were favorable for cleaning up the cotton crop in the northwestern portion of the belt, but during the second decade little progress was made, due to inclement weather; practically all cotton remaining

in the fields in Tennessee was picked during the last decade.

**Miscellaneous.**—The snow cover that obtained over Northern States during the first decade made much yard feeding of livestock necessary in the northern Great Plains. The colder weather during the second decade was very favorable for hog killing in southern sections. The range was generally snow-covered in most northern Rocky Mountain districts with new snow of benefit in other areas. There was a lack of adequate cover for meadows in the Lake region during the last decade; most of the ranges were closed in the northern Rockies. More snow was needed in lower portions of Colorado, but moisture was ample on most ranges of the Western States. Livestock continued good throughout the month, although some suffering with small losses was reported during the cold weather; feeding was general.

Rains over the Southeast improved winter truck the first part of the month, but the cold weather that overspread these sections during the latter part caused considerable injury to tender vegetation, although hardy truck was generally unharmed. Tobacco stripping was favored in most sections, although it was too dry for this work in Kentucky at the close of the month. Grinding sugar cane progressed favorably in Louisiana during the month; the freezes killed back cane shoots from early stubble. Citrus, as a whole, was uninjured by frost in Florida, and the showers and cooler weather were favorable. There was some firing necessary in California groves, but there was no serious injury. At the close of the month a severe cold wave was overspreading the Southeast, and this did much damage to truck and citrus at the beginning of January.

## WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

### NORTH ATLANTIC OCEAN

By F. A. Young

The weather over the North Atlantic for December was unusually severe, even for this month which is normally one of the stormiest of the year. Not only was the number of days with gales in excess of the normal, but the abnormal pressure distribution during a protracted period when a deep depression covered the region usually occupied by the North Atlantic HIGH, with anticyclonic conditions over northern Europe and Iceland, was responsible for winds of hurricane force, accompanied by dangerous confused and cross seas. As shown by reports in table of gales and storms, lowest barometric readings of slightly over 28 inches were recorded. According to the press reports there were many casualties, and in a number of cases vessels were days late in reaching port. Storm reports from nearly 150 vessels have been received up to time of writing, a number of which are given in table.

As is usually the case during a stormy month, the number of days with fog was below the normal over the Grand Banks and steamer lanes, although reported on seven days along the American coast between Hatteras and New York, on three days in the western section of the Gulf of Mexico, and on three days in the square between the 30th and 35th parallels and the 50th and 55th meridians.

TABLE 1.—Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (75th meridian), North Atlantic Ocean, December, 1927

Stations	Average pressure	Departure <sup>1</sup>	High-est	Date	Low-est	Date
	Inches	Inch	Inches		Inches	
Belle Isle.....	29.74	+0.04	30.44	8th.....	28.72	19th....
Halifax.....	29.92	-0.06	30.60	4th.....	28.90	20th....
Nantucket.....	30.00	-0.08	30.69	4th.....	28.28	14th....
Hatteras.....	30.11	-0.03	30.62	10th.....	29.64	16th....
Key West.....	30.08	-0.01	30.26	11th <sup>2</sup> .....	29.82	3d.....
New Orleans.....	30.17	+0.05	30.58	9th.....	29.78	12th....
Cape Gracias, Honduras.....	29.92	-0.06	30.00	25th.....	29.63	2d.....
Turks Island.....	30.06	+0.06	30.20	11th <sup>2</sup> .....	29.90	26th....
Bermuda.....	30.12	-0.03	30.62	11th.....	29.64	20th....
Horta, Azores.....	29.86	-0.22	30.42	3d.....	28.84	16th....
Lerwick, Shetland Islands.....	30.05	+0.36	30.80	28th.....	29.22	23d....
Valencia, Ireland.....	29.74	-0.20	30.53	28th.....	28.41	22d....
London.....	29.89	-0.12	30.62	28th.....	28.80	23d....

<sup>1</sup> From normals shown on H. O. Pilot Chart, based on observations at Greenwich mean noon, or 7 a. m. 75th meridian.

<sup>2</sup> And on other dates.

It is difficult to give a detailed description of the conditions, as storm after storm moved across the ocean in rapid succession and there was not a day when heavy weather was not reported from some locality.

From the 3d to 9th severe conditions prevailed over the middle and eastern sections of the steamer lanes, the storm area reaching its greatest extent on the 5th. On the 3d-4th strong gales also occurred in the vicinity of Hatteras.

From the 13th to 24th low pressure was general in the region between the Azores and Bermudas, and on the 15th to 17th the storm area extended nearly as far as the tropics. Charts VIII to XI show the conditions from the 15th to 18th, inclusive. This disturbance reached its greatest intensity on the 16th with the very steep pressure gradient between the Azores and Iceland, as shown on Chart IX.

On the 19th a strong "norther" prevailed in the Gulf of Mexico as shown by report in table.

From the 19th to 21st St. Johns, Newfoundland, was near the center of an area of low pressure and moderate to strong gales prevailed in the southerly quadrants.

On the 28th a well-developed low was central near 28° N., 57° W.; this moved eastward, increasing in intensity. On the 29th and 30th the center was near 33° N., 48° W., and on both dates northerly winds of hurricane force were reported by vessels in the westerly quadrants. On the 31st, when near 30° N., 45° W., there was a marked decrease in intensity with rising pressure.

## OCEAN GALES AND STORMS, DECEMBER, 1927

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From	To	Latitude	Longitude									
North Atlantic Ocean													
City of Flint, Am. S. S.	Middleborough	New York	53 18 N.	40 00 W.	Dec. 2	9a. 2	Dec. 4	29.04	WNW	WNW, 11	WNW	—, 12	Steady.
Mexican, Am. S. S.	Canal Zone	Charleston	31 27 N.	79 44 W.	3	Noon 3	4	29.64	NE	NE., 10	N	NE, 10	Do.
Westerdijk, Du. S. S.	Rotterdam	New York	46 20 N.	40 00 W.	3	2p. 4	5	29.56	NW	W, 9	NW	WNW, 11	WSW-WNW.
President Roosevelt, Am. S. S.	Cobb	do	50 58 N.	17 02 W.	5	5p. 6	9	28.71	W	SE	NW	WNW, 12	SE-S-W.
Wytheville, Am. S. S.	Rotterdam	do	47 30 N.	37 50 W.	4	9p. 6	9	29.04	WSW	W, 7	NNW	N, 12	SW-W.
Albert Ballin, Ger. S. S.	Southampton	do	48 40 N.	29 00 W.	6	4a. 7	8	29.05	SSE	W, 7	NW	WNW, 12	S-W.
Arkansas, Dan. S. S.	Norfolk	Denmark	54 57 N.	23 57 W.	5	4a. 8	9	28.50	NNW	SW, 8	SSE	NW, 11	—
Emanuel Nobel, Belg. S. S.	Antwerp	Philadelphia	48 00 N.	26 05 W.	7	8a. 9	10	29.06	W	WNW, 11	WNW	NNW, 12	W-SW-NW-N.
Hamburg, Ger. S. S.	New York	Cherbourg	46 06 N.	30 53 W.	13	8a. 14	14	28.93	NE	NW, 10	NW	NNE, 12	—
Jobshaven, Du. S. S.	Bremen	Savannah	32 54 N.	48 13 W.	14	6a. 15	16	29.30	NNW	WSW, 8	NW	W, 12	SSW-W.
Westerner, Am. S. S.	Antwerp	New York	37 19 N.	47 11 W.	15	11a. 15	16	28.17	W	—, 10	NNW	NW, 12	W-NNW.
Drechtidijk, Du. M. S.	do	Canal Zone	37 58 N.	35 16 W.	15	5p. 16	17	28.13	SSE	SW, 10	NW	W, 10	SSW-WSW.
Iroquois, Br. S. S.	London	Galveston	37 50 N.	34 08 W.	16	—, 16	17	28.30	SW	S, 10	NNW	WNW, 11	SW-WNW.
Topa Topa, Am. S. S.	Southampton	New Orleans	40 13 N.	32 40 W.	13	3p. 16	18	28.22	S	SSW, 9	W	W, 10	SSW-WNW.
Rockaway Park, Am. S. S.	Newport News	Manchester	45 46 N.	40 08 W.	16	4p. 18	18	28.61	—	WNW, 8	—	NW, 12	NW-WSW.
Tegucigalpa, Hond. S. S.	Vera Cruz	New Orleans	26 59 N.	91 00 W.	19	4a. 19	19	30.06	NE	NE., 8	—	—, 9	Steady.
Kifuku Maru, Jap. S. S.	Hamburg	New York	32 45 N.	56 50 W.	19	1a. 20	20	29.24	WSW	SW, 10	W	WSW, 11	Do.
West Zeda, Am. S. S.	do	Mobile	43 52 N.	25 14 W.	21	6p. 21	22	28.72	SSW	SW, 10	W	SW, 12	SSW-W.
Tulsa, Am. S. S.	Rotterdam	Jacksonville	44 01 N.	19 00 W.	21	—, 21	22	28.75	SW	SW, 12	SW	—, 12	WSW-W.
Emlyman, Br. S. S.	Montreal	Hamburg	58 35 N.	14 18 W.	27	10a. 28	28	28.80	SSE	NW, 12	NW	NW, 12	S-NW.
Waban, Am. S. S.	Rotterdam	Galveston	31 56 N.	50 40 W.	29	Noon 29	31	29.23	NNE	NNE	N	N, 12	NNE-N-W.
West Zeda, Am. S. S.	Hamburg	Mobile	30 12 N.	49 50 W.	30	8a. 30	31	29.26	NNW	NNW, 8	NNW	NNW, 12	Steady.
Cherco, Ital. S. S.	Valencia, Spain	New York	29 50 N.	59 40 W.	30	4a. 30	31	29.27	NW	NW, 10	NW	—, 10	Do.
North Pacific Ocean													
Steel Trader, Am. S. S.	Kobe	Manila	34 49 N.	135 38 E.	Nov. 30	2a. 1	Dec. 1	29.49	SSE	Calm	ENE	NE, 10	SW-0-NE.
Yogen Maru, Jap. S. S.	Muroran	Vancouver	49 55 N.	160 50 W.	Dec. 1	8a. 2	2	28.92	SSE	S, 10	SW	SSW, 11	1 point.
Steel Ranger, Am. S. S.	San Pedro	Yokohama	33 47 N.	174 10 W.	1	3p. 1	2	29.84	SSW	SW, 10	W	SW, 10	SSW-SW.
Oakridge, Am. S. S.	Yokohama	Portland	44 28 N.	161 34 E.	1	6a. 2	3	29.69	NNW	NW, 8	WNW	NW, 9	Steady.
Do	do	do	49 00 N.	175 54 E.	4	4a. 5	5	28.57	SSW	SSW, 7	SW	S, 11	SSW-SW.
Sunelisco, Am. S. S.	San Pedro	New York	15 17 N.	94 14 W.	3	2a. 3	4	29.76	NE	NNE	N	NE, 8	Steady.
Yoneyama Maru, Jap. S. S.	Wakamatsu	Astoria	48 56 N.	165 12 E.	3	2p. 4	6	28.66	SE	S, 4	WSW	W, 10	—
Do	do	do	50 00 N.	147 30 W.	7	9a. 7	8	29.06	SSE	SSE, 9	S	S, 9	SSE-S.
Steel Ranger, Am. S. S.	San Pedro	Yokohama	33 50 N.	168 00 W.	7	6p. 7	7	29.61	SSW	SW, 11	SW	SW, 12	SW-W.
Pres. Taft, Am. S. S.	San Francisco	do	32 50 N.	167 15 E.	7	—, 7	7	29.64	S	SW, 10	W	SW, 10	SSW-W.
Scottsburg, Am. S. S.	Manila	San Pedro	38 05 N.	161 41 E.	7	9a. 7	8	29.48	NW	NW, 7	NW	NW, 10	WNW-NW.
Wawala, Am. S. S.	Dairen	Portland	47 38 N.	178 28 E.	7	4a. 8	8	28.65	SE	SSW, 10	W	SSW, 11	SSW-SW.
West Nomentum, Am. S. S.	Portland	Nagoya	49 38 N.	175 20 E.	8	9a. 8	9	28.18	E	NE, 7	SW	NE, 9	NE-NW.
Manulani, Am. S. S.	Honolulu	San Francisco	22 00 N.	156 40 W.	8	5a. 8	10	29.68	ENE	ENE, 8	ESE	ESE, 6	ENE-ESE.
Tecumseh, Br. S. S.	Yokohama	San Pedro	36 14 N.	158 48 E.	9	Noon, 10	10	29.37	SSE	SW, 6	SW	SSE, 9	SE-S-SW.
Pres. Jefferson, Am. S. S.	San Francisco	Honolulu	37 16 N.	124 05 W.	9	10p. 9	11	29.82	WNW	WNW, 6	N	N, 9	NW-N.
Livingworth, Br. S. S.	Muroran	Vancouver	45 20 N.	164 50 E.	11	2p. 11	12	28.50	W	W, 8	W	W, 9	SW-W.
Edna, It. S. S.	Seattle	Colon	44 30 N.	125 10 W.	12	3p. 13	13	29.53	NW	SW, 9	N	W, 9	W-SW.
Scottsburg, Am. S. S.	Manila	San Pedro	43 38 N.	164 07 W.	14	5p. 14	15	29.72	S	S, 7	SSW	S, 9	S-SSW.
Steel Trader, Am. S. S.	Kobe	Manila	33 00 N.	164 56 E.	16	6p. 17	18	29.69	SSW	SSE, 10	SSW	SSE, 10	SSE-SSW.
Hayo Maru, Jap. S. S.	Muroran	Juan de Fuca	46 13 N.	177 08 E.	17	Mdt. 18	19	29.04	SE	SW, 10	WNW	WSW, 11	SSW-WSW.
West Cadron, Am. S. S.	Dairen	Portland	46 06 N.	165 40 E.	17	Noon, 18	19	28.12	E	S, 3	W	W, 10	E-S-W.
Yone Maru, Jap. S. S.	Muroran	Vancouver	49 10 N.	171 30 E.	18	5p. 22	23	29.00	SE	S, 3	SSW	NNW, 10	S-SSW.
Makiki, Am. S. S.	Hilo	Bellingham	37 34 N.	140 41 W.	23	Mdt. 23	24	29.96	NW	NW, 9	N	NW, 9	Steady.
Dilworth, Am. S. S.	Manila	San Francisco	39 30 N.	152 00 E.	23	8a. 24	24	28.85	SSE	SSW, 4	S	S, 11	SSW-S.
West Prospect, Am. S. S.	do	do	38 50 N.	157 20 E.	23	10p. 24	25	29.01	SW	SSW, 9	W	SSW, 10	S-SW.
Pres. Jefferson, Am. S. S.	Honolulu	Yokohama	26 48 N.	157 40 E.	24	2a. 25	25	29.71	SE	SW, 9	NW	SW, 9	S-SW-W.
Makana, Am. S. S.	Port Angeles	Napoopoo	41 28 N.	135 27 W.	24	6a. 24	25	29.45	N	NNW, 8	N	N, 9	N-NNW-N.
West Holbrook, Am. S. S.	Otaru	Portland	46 47 N.	167 24 E.	24	—, 24	25	28.47	ENE	SW, 7	SW	SW, 9	SSE-SW.
San Mateo, Am. S. S.	San Francisco	Cristobal	37 15 N.	122 40 W.	24	10p. 24	26	29.64	SE	SE, 8	N	ESE, 9	SE-S.
Atlantic Maru, Jap. S. S.	Kobe	San Francisco	42 45 N.	159 05 E.	25	10p. 24	27	28.63	S	S, 9	W	S, 11	S-WSW.
Tamaha, Br. S. S.	Shanghai	San Pedro	34 00 N.	138 00 E.	28	Noon, 29	29	29.38	NNW	W, 12	W	W, 12	NW-W.
West Hinton, Am. S. S.	Yokohama	Portland	46 10 N.	163 00 W.	29	3p. 29	29	29.04	SE	ESE, 9	SE	ESE, 9	ESE-SE.
Makawell, Am. S. S.	Ahukini	San Francisco	30 30 N.	143 51 W.	29	2a. 29	29	29.67	SSE	SSE, 7	SSE	SSE, 10	SSE-S.
Silverpine, Br. M. S.	San Francisco	do	27 25 N.	162 53 W.	25	Jan. 2	Jan. 3	29.63	SE	WNW, 9	WNW	W, 10	WNW-NW.

## NORTH PACIFIC OCEAN

By WILLIS E. HURD

Average atmospheric pressures over Aleutian waters and to the eastward, as in November, were above the normal, the greatest departures occurring over the Gulf of Alaska, especially the northeastern part. Pressure in the Aleutian Low fluctuated violently, but the average center of lowest pressure lay over the eastern Aleutians and adjoining waters. The North Pacific anticyclone was fairly well developed in middle latitudes east of the 180th meridian during the first two decades, thereafter it gave way to lower pressures until at the end of the month the whole eastern part of the Pacific was under cyclonic influences.

The following table gives pressure conditions for several island and coast stations in west longitudes:

TABLE 1.—Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, December, 1927

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	Inches	Inches		Inches	
Dutch Harbor <sup>1</sup>	29.61	+0.04	30.26	11th	28.88	13th
St. Paul <sup>1</sup>	29.65	+0.02	30.24	10th	29.10	13th
Kodiak <sup>1</sup>	29.74	+0.11	30.36	31st	28.80	3d
Midway Island <sup>1</sup>	30.03	-0.01	30.28	3d	29.76	22d
Honolulu <sup>1</sup>	29.93	-0.06	30.08	1st	29.73	25th
Juneau <sup>1</sup>	30.01	+0.22	30.61	8th	29.35	25th
Tatoosh Island <sup>1</sup>	30.04	+0.07	30.55	3d	29.37	27th
San Francisco <sup>1</sup>	30.05	-0.06	30.30	15th	29.70	24th
San Diego <sup>1</sup>	30.03	-0.01	30.27	13th	29.64	11th

<sup>1</sup> P. m. observations only.

<sup>2</sup> For 29 days.

<sup>3</sup> For 30 days.

<sup>4</sup> A. m. and p. m. observations.

<sup>5</sup> Corrected to 24-hour mean.

<sup>6</sup> And other dates.

The lowest recorded pressure reading of the month was 28.05 inches, by the American steamer *Wawalona*, in 47° 38' N., 175° 28' E.

Gales of force 8 or more were of daily occurrence somewhere on the sea. The area of severest and most

frequent storminess lay in east longitudes, along the upper steamer routes from the western Aleutians southward to the 40th parallel, 140th meridian, where gales occurred on more than 20 days. Abnormally frequent gales prevailed over the 10° square north of the Hawaiian Islands, bounded roughly east and west by the 150th and 160th meridians. The stormy periods here included the 7th to 10th, and the 25th to 30th. The higher wind forces, however, did not as a rule exceed 8 or 9. At Honolulu the maximum wind velocity was registered on the 7th, being at the rate of 49 miles an hour from the northeast. The prevailing monthly wind direction here was from the east.

Storm to hurricane gales over the ocean were reported on nine days, five in east and four in west longitudes. Hurricane velocities occurred on the 7th near 34° N., 168° W.; on the 28th off the Japanese coast southwest of Yokohama; and on the 30th and 31st at Tatoosh Island, the extreme velocities recorded at the Weather Bureau station here being 80 miles from the east, on the 30th, and 88 from the east, on the 31st. Gales of force 11 occurred within the 5° square, 45°-50° N., 180° and 175° E., on the 5th, 8th, and 18th.

Distinct lows derived from the prevailing oceanic cyclones entered the American continent on the 1st, 3d, 8th, 10th, 13th, 17th, 18th, 26th, and 27th.

At Honolulu and Juneau heavy precipitation occurred, this December being the rainiest on record at the former station, and one of the snowiest at the latter. It was the second coldest December on record at Juneau.

Light to moderate northers occurred in the Gulf of Tehuantepec, on the 2d, 22d, and 26th, but they were less frequent and severe than in November, none reported exceeding force 8.

Much less fog formed over the ocean than during November. Vessel reports show only two days with it in east longitudes, and only five days along the American coast. Roughly bounded, most frequent fog was observed between 45° and 51° N., 145° and 165° W., within which area it was encountered on 10 days.

CLIMATOLOGICAL TABLES<sup>1</sup>

## CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number or such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, December, 1927

Section	Temperature						Precipitation					
	Section average	Departure from the normal	Monthly extremes				Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date	Station	Amount	Station	Amount
Alabama	47.1	-0.2	3 stations	82	12	Riverton	10	9	Coffee Springs	14.84	Union Springs	3.57
Arizona	42.2	-2.0	Camel Back	85	2	Alpine	-17	15	Crown King	5.71	Tombstone	0.04
Arkansas	40.9	-1.6	Dumas	84	13	Gravette	-2	31	Lutherville	10.42	Thornburg	1.18
California	44.7	-1.4	Indio	89	2	Terro	-12	14	Big Sur	10.46	Middlewater	0.12
Colorado	20.4	-4.5	Holyoke	73	3	Dillon	-41	18	La Veta Pass	4.62	Garnett	0.00
Florida	59.5	-0.2	5 stations	88	1	Bluff Springs	22	9	Vernon	17.91	Miami Beach	0.21
Georgia	48.2	+0.6	Saint George	85	1	Blue Ridge	8	9	Clayton	12.64	Saint George	1.89
Idaho	20.4	-5.6	Pocahontas	63	2	Stanley	-38	31	Roland	7.11	Dubois	T.
Illinois	28.9	-1.6	Cairo	72	13	3 stations	-6	8	Anna	6.02	Moline (Airport)	1.52
Indiana	31.5	-0.6	3 stations	70	13	South Bend	-4	8	Salem	6.36	Greenfield	1.60
Iowa	18.7	-5.4	Keokuk	50	13	Sanborn	-22	8	Fayette	2.00	Cherokee	0.23
Kansas	27.6	-4.0	Ashtabula	72	12	Atwood	-18	18	Fredonia	2.40	Hugoton	0.00
Kentucky	37.4	-0.2	Williamsburg	77	13	2 stations	-1	9	Middlesboro	6.70	Mayfield	1.35
Louisiana	51.1	-1.2	Schriever	87	13	Tallulah	14	9	Elizabeth	11.97	Grand Cane	3.47
Maryland-Delaware	37.3	+2.2	3 stations	73	1	Grantsville, Md.	0	9	Public Landing, Md.	8.20	Picardy, Md.	1.62
Michigan	24.9	-0.1	2 stations	59	16	Humboldt	-25	12	Whitefish Point	5.83	Mio	0.73
Minnesota	3.8	-10.9	2 stations	46	14	Itasca State Park	-38	3	Mapleplain	3.89	Angus	0.11
Mississippi	47.2	-0.8	2 stations	81	12	Hernando	11	19	Natchez	11.89	Hernando	2.74
Missouri	29.9	-4.0	Campbell	74	13	Conception	-11	8	Koshkonong	7.84	Tarkio	0.52
Montana	9.6	-12.9	2 stations	62	1	Kenilworth	-51	31	Heron	4.95	Outlook	0.08
Nebraska	19.1	-6.7	Beaver City	68	12	Madrid	-28	31	2 stations	1.30	4 stations	T.
Nevada	29.0	-2.9	Las Vegas	79	1	2 stations	-23	14	Imley	1.72	2 stations	0.00
New England	29.2	+2.7	Rockport, Mass.	74	2	Enosburg Falls, Vt.	-17	27	Millinocket, Me.	7.34	Concord, N. H.	2.65
New Jersey	35.8	+2.6	Asbury Park	70	1	Runyon	2	27	Lambertville	5.76	Phillipsburg	2.80
New Mexico	30.8	-2.7	Carlsbad	72	9	Elizabethtown	-28	19	Tierra Amarilla	2.70	8 stations	T.
New York	28.7	+2.1	Cairo	70	1	Angelica	-14	25	High Market	8.10	Hudson	1.27
North Carolina	43.6	+1.1	2 stations	83	13	Banners Elk	0	9	Highlands	13.51	Goldboro	2.71
North Dakota	-1.8	-14.8	McKinney	43	5	Pettibone	-38	9	Power	3.80	2 stations	0.00
Ohio	31.9	+0.6	Portsmouth	73	13	Bangorville	0	9	Walbonding	6.33	Norwalk	1.86
Oklahoma	36.8	-2.4	2 stations	76	16	2 stations	-7	8	Durant	9.00	2 stations	T.
Oregon	31.2	-3.0	Brookings	77	4	Joseph	-23	31	Government Camp	13.94	Milton	0.08
Pennsylvania	32.7	+1.6	Newell	73	1	Bradford	-6	25	Grove City	8.93	Center Hall	2.16
South Carolina	45.2	-0.4	2 stations	83	12	Clemson College	12	26	Walhalla	11.38	Charleston	1.19
South Dakota	6.4	-13.1	Academy	55	12	2 stations	-38	18	Milbank	3.40	Fairfax	0.25
Tennessee	40.3	-0.2	3 stations	78	13	Rugby	0	20	Pheasant Field	11.38	Covington	1.70
Texas	45.6	-4.2	Ricardo	92	13	Romero	-6	8	Orange	11.01	Romero	T.
Utah	24.3	-2.3	Saint George	65	13	Woodruff	-27	15	Silver Lake	4.80	Castle Dale	T.
Virginia	39.2	+1.4	Roanoke	79	13	Burke Garden	1	9	Wallaceton	9.48	Winchester	2.45
Washington	27.5	-4.7	Wahluke	68	2	Chewelah	-33	31	Paradise Inn	17.38	Wahluke	T.
West Virginia	34.4	+0.8	Ravenswood	78	1	Bayard	-6	25	Bayard	6.78	Wardensville	0.42
Wisconsin	14.1	-5.9	Broddhead	49	28	Rest Lake	-41	9	Park Falls	3.55	Waukesha	0.67
Wyoming	14.2	-6.3	Fort Laramie (near)	68	3	Gallatin	-43	31	Alta	2.95	2 stations	T.
Alaska												
Hawaii	70.3	+0.5	Kaanapali	91	13	Glenwood	42	31	Pihonua	65.74	Puu Koa	5.10
Porto Rico	74.6	+0.1	Santa Rita	94	11	Cayey	81	20	Barros	11.14	2 stations	0.00

## LATE REPORTS

Hawaii (November)	72.9	+1.3	3 stations	90	12	Glenwood	50	20	8.34	+0.31	Olokele (mauka)	37.80	3 stations	0.00
Alaska (November)	16.2	-8.7	Ketchikan	59	1	Wonder Lake	-56	26	3.02	-3.03	Calder	12.29	Rampart	T.

<sup>1</sup> For description of tables and charts, see REVIEW, January, 1927, p. 43.

<sup>2</sup> Other dates also.

TABLE 1.—Climatological data for Weather Bureau stations, December, 1927

District and station	Elevation of instruments			Pressure			Temperature of the air										Precipitation			Wind					Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month					
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. +2	Mean min. -2	Departure from normal	Maximum	Date	Mean minimum	Date	Mean maximum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Total	Departure from normal	Days with .01 or more	Total movement				Prevailing direction	Maximum velocity			
																													Miles per hour	Direction	Date	
New England																																
Eastport	76	67	85	29.84	29.92	-0.06	29.7	+3.4	57	1	37	7	4	23	37	28	24	79	4.41	+0.4	16	10,744	nw.	53	a.	17	4	4	23	8.0	22.6	0.0
Greenville, Me.	1,070	6		28.76	29.96	-0.20	28.2	+1.0	51	8	29	1	4	15	30				4.77	-0.7	14	7,074	nw.	35		24	4	4	23	31.0		
Portland, Me.	103	82	117	29.88	30.01	-0.13	29.7	+3.1	62	1	38	10	4	24	35	27	22	71	5.50	+1.8	12	7,531	n.	42	a.	8	10	7	14	6.0	18.4	1.0
Concord	289	70	79	29.08	30.00	-0.06	27.8	+1.0	62	1	36	5	27	19	41				2.65	-0.7	12	3,061	nw.	21	nw.	1	7	10	14	6.6	12.9	0.5
Burlington	403	11	48	29.56	30.02	-0.46	29.0	+1.6	58	8	32	0	4	20	34				3.73	+2.0	15	8,386	a.	46	a.	20	0	8	23	8.0	17.5	0.5
Northfield	876	12	60	29.04	30.03	-0.02	24.2	+3.8	65	1	33	8	27	16	49	22	20	85	4.26	+1.6	16	5,483	n.	30	a.	8	1	9	21	8.1	18.0	2.7
Boston	125	115	188	29.86	30.00	-0.14	29.6	+2.5	65	1	44	13	24	28	36	32	27	71	5.23	+1.8	10	8,973	w.	40	a.	16	10	9	12	5.6	T.	0.0
Nantucket	12	14	90	29.97	29.98	-0.01	29.7	+3.7	61	1	45	19	24	32	25	35	31	78	5.49	+1.8	12	13,343	nw.	57	sw.	10	7	8	16	6.5	T.	0.0
Block Island	26	11	46	29.96	29.99	-0.03	29.6	+2.0	61	1	44	16	24	32	30	36	32	78	4.03	-0.2	11	17,821	nw.	67	w.	16	9	8	14	6.0	T.	0.0
Providence	160	215	251	29.83	30.01	-0.18	29.6	+3.4	63	1	43	14	24	27	35	31	25	60	4.69	+0.8	11	11,033	nw.	56	nw.	1	14	3	14	5.4	0.0	0.0
Hartford	159	122		29.85	30.03	-0.18	29.6	+3.2	62	1	40	10	24	26	34				5.28	+1.7	11		nw.	57		13	6	12	5.4	T.	0.0	
New Haven	106	74	163	29.92	30.04	-0.12	29.8	+1.7	62	1	41	11	24	27	33	31	26	75	5.00	+2.0	11	8,240	n.	37	sw.	8	9	9	13	5.9	2.0	0.0
Middle Atlantic States																																
Albany	97	102	115	29.95	30.06	-0.11	29.8	+2.1	64	1	37	8	24	24	35	28	24	80	3.61	+1.0	12	5,735	nw.	33	w.	1	6	8	17	6.7	5.6	0.0
Binghamton	871	10	84	29.10	30.06	-0.03	29.4	+2.2	63	14	37	7	24	24	40				3.64	+1.2	17	5,234	nw.	36	nw.	14	2	11	18	7.7	14.2	T.
New York	314	414	454	29.72	30.07	-0.35	29.6	+1.6	67	1	44	15	24	29	38	32	26	69	3.39	-0.1	11	16,178	nw.	70	nw.	14	9	10	12	6.2	2.4	0.0
Harrisburg	374	94	104	29.70	30.12	-0.42	29.4	+2.2	64	14	42	14	9	28	41	31	25	70	3.33	+0.7	12	6,520	nw.	32	a.	8	8	4	19	7.2	T.	0.0
Philadelphia	114	123	182	29.96	30.09	-0.13	29.8	+2.0	67	1	46	18	25	32	38	35	29	70	3.99	+1.0	13	8,137	nw.	35	se.	3	9	6	16	6.2	T.	0.0
Reading	325	81	98	29.72	30.09	-0.37	29.4	+2.0	68	1	43	16	9	29	30	32	28	77	4.38	+1.1	11	6,363	nw.	41	se.	16	8	8	15	6.0	2.7	0.0
Scranton	905	111	119	29.20	30.06	-0.86	29.2	+1.5	60	8	39	12	24	26	41	30	28	86	3.64	+1.0	15	6,031	a.	34	se.	7	3	7	12	7.6	2.6	0.0
Atlantic City	62	37	172	30.01	30.07	-0.06	29.9	+2.7	66	1	46	16	25	32	32	36	31	78	4.94	+1.1	13	16,046	nw.	68	ne.	4	11	7	13	5.5	T.	0.0
Cape May	17	13	49	30.04	30.06	-0.02	29.8	+0.9	66	1	46	18	10	32	36	36	32	78	4.79	+1.1	11	15,888	nw.	56	w.	16	11	7	13	5.8	T.	0.0
Sandy Hook	22	10	55	30.04	30.06	-0.02	29.8	+0.9	66	1	46	18	10	32	36	36	32	78	4.79	+1.1	11	15,888	nw.	56	w.	16	11	7	13	5.8	T.	0.0
Trenton	196	159	183	29.86	30.07	-0.21	29.6	+2.8	68	1	45	16	25	29	40	33	28	72	5.36	+2.2	12	9,829	nw.	47	nw.	1	9	6	17	6.3	T.	0.0
Baltimore	123	100	216	29.96	30.10	-0.14	29.8	+2.8	71	1	47	18	9	32	39	35	29	69	3.61	+0.5	14	8,766	sw.	44	sw.	1	10	6	15	6.3	T.	0.0
Washington	112	62	85	29.98	30.10	-0.12	29.8	+2.5	70	1	46	16	19	31	39	34	28	68	3.51	+0.4	13	6,274	nw.	38	ne.	1	11	6	14	5.7	T.	0.0
Cape Henry	18	8	54	30.07	30.09	-0.02	29.8	+0.6	75	13	53	24	20	38	54	41	36	74	5.81	+2.4	12	12,985	sw.	67	ne.	4	10	8	13	5.6	T.	0.0
Lynchburg	681	153	188	29.36	30.13	-0.77	29.3	+0.6	75	13	50	15	26	30	38	34	28	66	3.88	+0.6	10	6,505	w.	42	nw.	31	15	6	10	4.6	0.6	0.0
Norfolk	91	170	205	30.01	30.12	-0.11	29.9	+1.4	74	13	52	23	9	37	40	35	73	5.99	+2.5	9	11,730	n.	56	w.	16	11	9	11	5.6	0.0	0.0	
Richmond	144	11	52	29.97	30.13	-0.16	29.8	+1.2	77	13	50	18	10	32	36	36	31	74	5.02	+2.0	12	6,945	sw.	39	w.	8	15	3	13	4.7	T.	0.0
Wytheville	2,304	49	55	27.69	30.15	-0.46	27.2	+0.3	70	13	45	8	9	26	44	30	26	75	5.01	+1.3	11	5,414	w.	40	w.	31	12	7	12	5.3	7.1	T.
South Atlantic States																																
Asheville	2,253	70	84	27.72	30.16	-0.44	27.3	+1.1	71	13	49	9	9	29	42	34	29	75	6.41	+3.3	12	8,064	se.	37	n.	8	13	8	10	4.8	1.6	0.0
Charlotte	779	55	62	29.28	30.14	-0.86	28.4	+0.4	72	13	53	20	9	34	35	38	34	73	9.52	+6.7	11	4,473	ne.	29	ne.	4	12	5	14	5.1	1.3	0.0
Hatteras	11	11	50	30.08	30.09	-0.01	29.9	+0.5	73	2	56	29	20	44	22	47	43	80	5.54	+0.4	10	12,814	n.	52	n.	1	15	7	9	4.6	0.0	0.0
Raleigh	376	103	110	29.72	30.14	-0.42	29.3	+0.8	77	13	53	21	10	34	32	39	35	76	6.47	+3.3	12	6,656	ne.	37	ne.	4	13	5	13	5.4	0.0	0.0
Wilmington	78	81	91	30.05	30.14	-0.09	29.9	+0.5	80	13	59	25	20	40	29	44	40	75	3.27	+0.2	11	5,787	n.	31	ne.	4	13	5	14	5.2	0.0	0.0
Charleston	48	11	92	30.08	30.13	-0.05	29.9	+0.9	78	13	59	26	20	42	32	46	43	78	1.19	-2.0	6	7,922	n.	38	n.	3	11	5	15	5.9	0.0	0.0
Columbia, S. C.	351	41	57	29.76	30.15	-0.39	29.4	+0.8	78	13	57	21	20	37	31	41	35	70	7.39	+4.5	11	5,438	n.	34	sw.	31	12	5	14	5.5	0.0	0.0
Due West	711	10	55	29.37	30.16	-0.79	28.9	+0.6	73	13	54	17	20	34	36				8.61	+2.0	12	7,992	ne.	54	ne.	3	12	6	13	5.3	0.0	0.0
Greenville, S. C.	1,039	139	146	29.01	30.13	-0.12	29.0	+1.9	70	14	53	18	20	36	33	39	34	75	9.86	+2.0	12	6,378	ne.	62	ne.	4	11	6	14	5.3	0.0	0.0
Augusta	182	62	77	29.94	30.14	-0.20	29.8	+0.1	78	13	58	22	20	38	29	43	40	80	7.26	+3.8	10	4,897	nw.	42	ne.	3	9	6	16	6.1	0.0	0.0
Savannah	65	150	194	30.07	30.14	-0.07	29.9	+0.1	79	13	62	24	20	43	33	40	42	77	2.98	-0.1	6	9,362	w.	43	ne.	3	11	3	17	5.8	T.	0.0
Jacksonville	43	200	245	30.09	30.14	-0.05	29.9	+0.7	83	1	65	27	20	46	27	50	46	75	2.75	-0.2	7	8,934	n.	39	sw.	31	8	9	14	5.0	0.0	0.0
Florida Peninsula																																
Key West	22	10	64	30.05	30.07	-0.02	29.9	+0.3	83	10	76	56	21	66	20	65	63	79	0.78	-1.1	6	8,534	ne.	28	ne.	3	14	9	8	4.5	0.0	0.0
Miami	25	71	164	30.08	30.11	-0.03	29.9	+0.6	82	16	74	38	21	61	29	61	57	74	0.52	-1.5	7	8,697	e.	33	ne.	27	9	10	12	5.0	0	

TABLE 1.—Climatological data for Weather Bureau stations, December, 1927—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air										Precipitation			Wind												
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. + min.	Departure from normal	Maximum	Date	Mean minimum	Date	Mean maximum	Greatest daily range	Mean wet thermometer	Mean temperature of dew-point	Mean relative humidity	Total	Departure from normal	Days with 0.1 or more	Total movement	Prevailing direction	Maximum velocity			Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month	
																							Miles per hour	Direction	Date							
Ohio Valley and Tennessee	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	In.	In.	Miles									0-10	In.	In.	
Chattanooga	762	189	213	29.34	30.17	+ .01	43.0	-0.3	72	13	52	13	9	34	35	37	30	63	7.31	+3.0	13	7.204	sw.	37	sw.	7	13	5	13	5.1	T.	T.
Knoxville	995	102	111	29.08	30.17	+ .01	40.6	-0.3	69	13	30	12	9	32	35	35	30	71	5.14	+1.0	12	4.968	n.	38	sw.	13	13	5	12	4.9	T.	0.0
Memphis	399	76	97	29.74	30.18	+ .03	41.2	-2.4	76	19	50	9	31	33	44	37	32	72	2.64	-1.7	7	6.488	w.	39	w.	7	13	5	14	5.2	T.	0.0
Nashville	546	168	191	29.59	30.19	+ .04	40.2	-0.8	73	13	49	8	31	31	50	35	30	70	2.60	-1.1	10	8.331	nw.	46	w.	7	17	0	14	4.8	T.	0.0
Lexington	989	193	230	29.07	30.18	+ .04	35.0	-0.8	70	19	43	2	31	27	51	32	30	73	3.64	+0.2	13	10.821	sw.	50	w.	13	11	3	17	5.6	0.4	0.1
Louisville	523	188	224	29.56	30.17	+ .03	35.8	-1.8	70	19	44	3	31	28	53	32	28	73	2.89	-0.9	10	9.322	s.	60	sw.	7	14	5	12	5.1	0.1	T.
Evansville	431	76	116	29.70	30.18	+ .05	35.6	-1.5	68	13	44	1	31	28	44	32	27	73	4.38	+0.9	8	7.804	s.	45	w.	7	15	4	12	4.6	0.4	0.3
Indianapolis	822	194	230	29.21	30.13	+ .01	30.8	-1.4	65	13	39	1	31	23	44	32	23	74	2.99	0.0	9	10.053	s.	46	sw.	7	11	7	13	5.4	0.9	0.3
Royal Center	736	11	55	29.29	30.12	+ .02	28.9	-1.1	61	12	35	1	31	19	44	32	23	74	3.45	0.0	8	9.242	w.	50	w.	7	11	7	13	5.4	0.9	0.3
Terre Haute	575	96	129	29.49	30.15	+ .02	31.3	-0.6	64	12	39	1	31	23	45	32	28	73	3.70	+0.6	9	8.172	s.	38	sw.	7	12	7	12	5.4	0.6	0.2
Cincinnati	637	11	51	29.44	30.15	+ .02	33.4	-0.0	67	13	42	6	31	19	25	47	30	76	3.48	+0.6	9	7.016	sw.	39	sw.	7	11	4	16	5.8	0.1	T.
Columbus	822	179	222	29.22	30.12	+ .00	32.8	-0.4	64	13	40	6	31	19	25	48	30	78	3.55	+0.8	12	8.869	s.	40	w.	31	7	3	21	7.2	0.5	T.
Dayton	890	137	173	29.14	30.13	+ .02	32.8	-0.2	65	13	40	6	31	25	46	30	77	2.49	-0.1	11	8.616	sw.	52	w.	7	7	6	18	7.2	1.2	0.6	
Elkins	1,947	59	67	28.03	30.17	+ .05	32.6	-0.1	68	13	42	4	9	23	50	29	25	81	3.43	0.0	19	5.068	w.	36	nw.	14	5	6	20	7.5	2.2	T.
Parkersburg	637	77	82	29.48	30.16	+ .02	32.6	-0.8	70	13	44	10	9	28	48	31	27	76	3.64	+0.9	14	5.306	sw.	36	sw.	8	6	4	21	7.7	1.9	T.
Pittsburgh	842	353	410	29.18	30.12	+ .01	33.8	-0.4	64	13	41	6	9	27	49	30	26	76	3.16	+0.4	12	10.262	w.	47	sw.	8	5	4	22	7.9	1.8	T.
Lower Lake Region							39.1	+0.9									86	3.57	+0.7										7.6			
Buffalo	767	247	280	29.18	30.04	- .02	30.4	+0.6	59	8	36	8	9	24	47	28	25	83	4.01	+0.8	20	16,006	w.	86	sw.	8	4	7	20	8.0	7.0	0.0
Canton	448	10	61	29.53	30.03	- .02	24.4	+1.7	58	8	31	-9	24	18	40	25	23	83	4.17	+0.6	18	7,098	w.	48	w.	8	7	5	19	7.3	17.5	T.
Oswego	335	76	91	29.53	30.04	- .02	29.8	+0.8	57	13	36	7	24	23	33	22	79	3.12	-0.5	20	10,813	nw.	38	sw.	8	0	2	29	17.1	17.1	0.0	
Rochester	523	86	102	29.46	30.06	- .00	29.8	+0.5	59	13	36	7	25	24	42	27	23	76	3.07	+0.2	20	7,470	sw.	43	sw.	8	3	4	24	8.6	13.4	0.0
Syracuse	597	97	113	29.40	30.07	- .01	29.6	+1.3	60	8	36	2	24	24	42	22	79	3.80	+1.2	20	9,068	w.	50	sw.	8	3	3	27	8.5	20.0	T.	
Erie	714	130	166	29.27	30.06	- .01	32.1	+0.2	63	13	39	9	9	26	48	29	25	75	4.60	+1.5	19	12,742	s.	62	sw.	8	3	5	23	8.4	13.1	0.0
Cleveland	762	190	201	29.23	30.08	- .01	32.2	+0.1	62	13	39	7	9	26	36	29	25	78	3.91	+1.3	18	9,926	sw.	44	w.	19	5	4	22	8.0	7.2	0.6
Sandusky	629	5	67	29.40	30.11	+ .02	31.9	+0.7	61	13	39	6	9	25	42	29	25	78	3.29	+0.9	14	8,928	sw.	44	sw.	8	5	7	19	7.3	4.2	3.0
Toledo	628	208	243	29.39	30.10	+ .02	31.0	+0.6	60	13	37	6	9	25	24	28	24	76	3.38	+1.1	9	11,882	sw.	65	sw.	8	11	4	16	6.4	2.9	2.4
Fort Wayne	856	113	124	29.13	30.09	- .00	29.0	+1.7	60	13	36	3	31	22	38	27	24	82	3.14	-0.2	10	8,038	sw.	42	sw.	7	9	6	16	6.5	2.2	2.0
Detroit	730	218	258	29.25	30.07	- .00	30.4	+1.1	56	13	36	7	9	24	29	28	25	82	2.39	0.0	12	9,624	sw.	60	sw.	8	6	10	15	7.1	5.4	5.6
Upper Lake Region							21.5	-2.9									84	2.83	+0.7										7.4			
Alpena	609	13	92	29.32	30.01	- .01	25.6	+0.8	45	29	31	1	9	20	35	24	21	83	2.10	-0.1	13	9,284	nw.	52	s.	8	4	3	24	8.1	12.3	2.8
Escanaba	612	54	60	29.33	30.09	- .01	26.4	+0.0	38	29	24	-20	9	8	40	15	13	87	3.17	+1.5	10	8,420	nw.	48	n.	7	9	9	13	6.1	27.4	10.0
Grand Haven	632	54	89	29.34	30.05	- .00	27.8	-1.5	48	7	34	8	8	22	21	26	24	86	2.47	0.0	15	10,813	w.	52	w.	8	3	5	23	8.3	12.0	4.0
Grand Rapids	707	70	87	29.27	30.08	+ .01	28.0	-0.5	52	12	34	8	8	22	26	26	22	79	3.16	+0.6	14	5,477	nw.	27	w.	8	1	5	25	8.6	17.0	5.5
Houghton	668	64	99	29.27	30.03	+ .01	15.8	-6.0	39	26	22	-8	9	9	28	26	22	79	5.30	+2.9	10	8,881	w.	40	e.	18	1	7	23	8.5	53.8	16.6
Lansing	878	11	62	29.12	30.06	- .01	28.9	-0.3	53	13	34	5	9	20	31	25	24	90	3.11	+1.0	13	5,579	nw.	33	sw.	8	8	10	13	6.3	12.5	1.1
Ludington	687	66	66	29.31	30.03	- .01	18.5	-4.2	45	7	33	4	8	21	27	25	23	84	2.22	-0.2	15	10,510	w.	57	w.	7	1	6	24	8.7	10.3	1.7
Marquette	734	77	111	29.19	30.03	+ .01	28.2	+1.6	53	13	35	7	9	12	34	16	14	84	3.19	+0.7	20	8,282	sw.	46	nw.	8	4	7	20	7.9	29.8	14.4
Port Huron	636	70	120	29.33	30.05	- .01	28.2	+1.6	53	13	35	7	9	12	34	16	14	84	3.19	+0.7	20	8,282	sw.	46	nw.	8	4	7	20	7.9	29.8	14.4
Sault Sainte Marie	614	11	52	29.28	30.01	- .01	19.6	-0.9	38	29	26	-7	3	13	21	15	15	84	3.50	+1.2	20	8,230	nw.	39	nw.	8	2	3	26	8.7	31.5	8.4
Chicago	673	7	131	29.34	30.10	+ .02	26.9	-1.9	52	12	34	-1	31	20	43	24	20	76	2.74	+0.7	9	9,698	sw.	50	sw.	7	9	8	14	6.2	9.6	9.1
Green Bay	617	109	141	29.36	30.06	+ .02	16.7	-5.6	41	28	25	-14	9	8	39	16	13	84	1.89	+0.1	11	9,074	w.	39	nw.	7	0	5	20	7.0	14.5	3.6
Milwaukee	681	125	221	29.30	30.07	+ .01	23.2	-2.9	46	26	31	-1	8	16	41	21	16	74	1.22	-0.7	8	12,222	w.	48	nw.	8	8	7	16	6.4	2.7	1.8
Duluth	1,133	5	47	28.79	30.09	+ .04	5.5	-10.4	32	28	14	-26	9	-2	33	4	3	95	1.97	+0.8	11	11,029	nw.	70	nw.	7	14	0	11	4.8	19.7	21.8
North Dakota							-1.5	-18.5									86	1.63	+0.4										7.6			
Moorhead	940	50	58	29.10	30.20	+ .12	0.6	-10.9	37	5	9	-24	9	-8	43	0	-2	92	2.28	+1.8	12	7,133	n.	20	nw.	15	10	8	13	6.0	29.2	13.6
Bismarck	1,474	8	57	28.31	30.24	+ .16	-2.4	-17.1	37	5	7	-30	10	-12	54	-4	-7	90	1.20	+0.6	8	6,541	nw.	32	nw.	5	11	9	11	4.8	20.4	10.4
Devils Lake	1,478	11	44	28.50	30.20	+ .14	-1.4	-9.4	38	5	7	-24	8	-10	50	-3	-5	90	0.06	-0.3	2	6,731	nw.	29	nw.	5	14	9	8	4.8	1.2	1.2
Eliandale	1,457	10	56	28.52	30.19	- .05	-0.6	-3.5	37	5	8	-25	9	-9	49	-	-	90	1.04	-0.3	10	11,825	nw.	48	nw.	31	9	8	14	6.1	15.0	4.5
Grand Forks	833	12	67	28.52	30.19	- .05	1.2	-3.5	36	5	9	-																				

TABLE 1.—Climatological data for Weather Bureau stations, December, 1927—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air										Precipitation			Wind					Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month						
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max. min. +2	Departure from normal	Maximum	Date	Mean minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Total	Departure from normal	Days with .01 or more	Total movement	Prevailing direction	Maximum velocity													
																							Miles per hour	Direction							Date					
Northern Slope																																				
Billings	3,140	8					12.3	-11.0										79	0.89	0.0																
Hayden	2,503	11	44	27.40	30.23	+18	13.6	-19.2	44	4	12	33	7	9	53	1	12	86	0.91	+0.3	10	5,039	e.	35	sw.	4	11	9	11	5.6	8.6	0.2				
Helena	4,110	87	112	25.78	30.19	+06	11.6	-12.6	57	2	19	28	31	4	51	10	82	0.85	0.0	11	4,706	sw.	41	sw.	2	2	13	16	7.4	14.1	7.7					
Kalispell	2,973	48	56	26.95	30.16	+09	13.7	-11.2	51	2	20	24	31	7	36	14	12	89	1.69	-0.2	15	3,673	nw.	38	ne.	5	4	7	20	7.7	15.8	11.5				
Miles City	2,371	48	55		30.26		3.7	-17.3	44	4	12	31	31	4	33			68	1.33	+0.7	14	3,360	nw.	30	n.	5	17	5	9		14.0	12.0				
Rapid City	3,250	50	58	26.50	30.22	+13	13.6	-13.3	50	12	24	18	31	4	54	10	4	08	0.57	+0.1	7	5,174	n.	32	n.	3	13	6	12	4.8	5.8	0.8				
Cheyenne	6,088	84	101	23.87	30.07	+02	21.4	-7.1	49	5	33	19	31	10	55	17	6	61	0.47	+0.2	5	10,092	w.	55	w.	14	10	12	9	5.0	5.8	1.5				
Lander	5,372	60	68	24.56	30.17	+02	14.2	-6.2	55	2	27	23	7	1	55	10	6	76	0.65	0.0	5	3,008	sw.	48	sw.	13	11	13	7	8.2	7.0	1.0				
Sheridan	3,790	10	47	26.06	30.17	+11	5.5	-5.7	57	2	24	32	31	0	40	8	5	81	0.76		12	2,983	nw.	27	nw.	16	13	11	7	8.2	5.9	3.7				
Yellowstone Park	6,241	11	48	23.7	30.17	+01	11.6	-10.0	40	2	21	30	31	2	30	10	7	80	1.18	-0.6	16	5,716	s.	42	s.	12	4	12	15	7.0	12.0	7.7				
North Platte	2,821	11	54	27.06	30.17	+07	19.4	-7.3	55	12	33	14	8	6	47	14	10	78	0.38	-0.1	5	3,939	w.	35	n.	6	18	4	9	4.2	3.8	1.0				
Middle Slope																																				
Denver	5,292	106	113	24.64	30.08	+00	25.9	-6.4	58	2	38	12	7	14	48	20	13	63	0.23	-0.4	4	5,383	s.	38	nw.	3	16	10	5	2.7	4.8	0.3				
Pueblo	4,685	80	86	25.23	30.08	+00	25.6	-5.0	61	3	40	10	31	11	50	21	14	63	0.70	+0.2	6	4,347	w.	40	nw.	28	19	10	2	2.7	7.0	0.3				
Concordia	1,392	50	58	28.62	30.16	+05	23.8	-6.9	61	3	35	7	31	13	43	20	15	76	0.36	-0.1	6	6,747	nw.	40	nw.	7	11	9	11	5.2	3.1	1.3				
Dodge City	2,509	11	51	27.45	30.16	+06	27.5	-5.1	64	3	42	4	31	14	48	21	14	65	0.02	-0.5	1	7,383	sw.	37	nw.	6	21	5	5	2.9	0.3	T.				
Wichita	1,358	139	158	28.65	30.14	+03	29.6	-5.0	63	0	40	5	31	19	48	26	18	64	0.53	0.0	5	10,377	s.	44	s.	6	16	6	9	4.3	2.7	2.4				
Broken Arrow	765	11	56	29.32	30.18	+35.4			65	12	46	0	31	25	42			1.46		7	9,668	s.	48	nw.	13	12	4	15	3.6	T.	T.					
Oklahoma City	1,214	10	47	28.84	30.16	+05	35.0	-4.3	66	6	45	1	31	25	34	30	22	64	1.23	-0.5	5	8,401	s.	39	nw.	7	13	6	12	3.2	0.6	0.6				
Southern Slope																																				
Abilene	1,738	10	52	28.30	30.15	+04	42.0	-4.0	69	12	52	12	31	32	39	35	27	60	0.56	-0.6	5	7,306	s.	38	sw.	9	6	10	15	6.4	0.1	0.0				
Amarillo	3,676	10	49	26.27	30.10	+01	34.6	-2.4	64	3	46	3	31	23	49	28	19	59	0.47	-0.4	4	7,421	sw.	35	w.	14	13	5	13	5.2	0.1	0.0				
Del Rio	944	64	71	29.12	30.13	+03	46.8	-5.4	76	30	55	24	10	39	31	41	36	72	0.37	-0.5	8	5,083	se.	33	n.	31	11	1	19	6.6	0.9	0.0				
Roswell	3,566	72	85	26.39	30.09	+02	36.0	-6.2	65	12	43	7	19	24	46	30	22	64	0.35	-0.2	5	5,502	s.	37	n.	3	14	7	16	4.4	2.5	0.5				
Southern Plateau																																				
El Paso	3,778	152	175	26.22	30.07	+04	42.5	-2.4	63	9	51	24	16	34	31	30	27	59	0.72	+0.2	6	7,502	w.	42	w.	27	15	5	11	4.5	1.2	0.0				
Santa Fe	7,013	38	53	23.17	30.09	+03	27.0	-3.7	50	3	36	5	18	17	29	21	14	62	0.44	-0.3	5	4,805	n.	30	n.	15	19	7	5	3.2	2.4	0.6				
Flagstaff	6,907	10	59	23.27	30.02	+04	25.0	-3.4	56	2	37	7	16	13	45	22	14	74	1.85		10	6,727	w.	37	nw.	15	16	6	9		12.0	5.2				
Phoenix	1,103	10	82	28.84	30.02	+02	50.9	-1.1	77	2	63	28	17	39	39	42	38	58	1.30	+0.7	6	3,430	e.	26	e.	4	15	9	7	3.7	0.0	0.0				
Yuma	141	9	54	29.89	30.04	+01	53.0	-2.2	79	3	64	35	13	42	35	44	32	52	1.50	+1.0	3	4,714	n.	37	n.	4	24	4	3	1.9	0.0	0.0				
Independence	3,957	5	25	25.96	30.06	+06	37.0	-2.3	74	2	48	10	12	26	33	28		0.29	-0.6	2		n.			17	1	13		T.	0.0						
Middle Plateau																																				
Reno	4,532	74	81	25.48	30.13	-02	31.8	-1.9	60	2	43	11	18	20	36	27	21	69	0.28	-0.9	4	3,745	w.	34	w.	13	18	6	7	3.6	3.9	0.0				
Tonopah	6,090	12	20				29.6		50	2	37	10	18	22	19	24	16	61	0.17		4		se.													
Winnemucca	4,344	18	56	25.68	30.21	+03	24.4	-5.6	57	2	38	9	30	11	37	20	15	67	1.10	+0.1	5	5,426	ne.	45	sw.	13	12	15	4	4.1	9.0	3.2				
Modena	5,473	10	43	24.60	30.12	+00	21.8	+0.3	55	2	34	11	14	10	43	18	13	76	0.91	+0.3	7	6,673	w.	48	sw.	9	16	6	9	4.0	11.4	1.5				
Salt Lake City	4,360	163	203	25.64	30.13	-02	27.8	-4.1	53	2	34	9	18	21	27	25	20	73	1.94	+0.6	12	4,227	s.	48	nw.	3	8	7	16	6.6	25.0	9.0				
Grand Junction	4,602	60	68	25.39	30.07	-03	25.8	-1.7	50	2	36	2	31	16	29	22	16	69	0.91	+0.5	10	3,070	se.	23	w.	6	12	12	7	4.7	9.1	3.8				
Northern Plateau																																				
Baker	3,471	48	53	26.48	30.19	+03	20.4	-6.9	55	2	30	15	31	11	28	19	15	77	1.15	-0.4	14	4,533	se.	26	nw.	5	6	7	18	7.1	13.6	6.0				
Boise	2,739	78	86	27.25	30.21	+01	28.0	-4.1	55	2	35	5	31	21	21	25	20	73	0.61	-1.1	11	2,940	se.	29	nw.	2	5	12	14	6.8	4.4	T.				
Lewiston	757	40	49	29.31	30.16	+03	27.6	-4.1	61	2	34	5	31	21	27			1.16	-0.4	11	3,995	e.	39	nw.	2	9	8	19	7.0	4.9	1.8					
Pocatello	4,477	60	68	25.46	30.15	+04	22.2	-5.5	52	2	30	2	31	14	34	20	15	72	1.31	+0.4	11	7,741	se.	38	s.	13	7	10	14	6.5	17.7	5.0				
Spokane	1,929	101	110	28.01	30.14	+06	21.6	-4.1	53	2	29	5	31	14	27	21	19	87	1.55	-0.6	12	3,668	e.	34	sw.	2	3	8	20	7.7	15.0	8.7				
Walla Walla	901	57	65	29.05	30.16	+04	30.2	-5.9	62	2	37	2	31	24	37	28	24	76	0.58	-1.5	9	3,652	sw.	30	w.	5	4	8	22	7.9	3.8	1.3				
North Pacific Coast Region																																				
North Head	211	11	56	29.81	30.04	+01	40.6	-3.3	53	1	45	20	31	26	19	30	36	83	4.22	-4.1	22	12,407	se.	62	s.	11	1	8	22	8.5	1.6	0.1				
Port Angeles	29	8	53	30.06	30.09	+07	37.0		55	1	43	15	30	32	19			2.88	-2.3	18	5,233	sw.	40	n.	9	1	11	19	7.9	8.5	2.2					
Seattle	125	215	250	29.95	30.08	+07	38.0	-3.7	56	1	42	17	30	34	16	36	53	81	3.33	-2.1	16	6,664	se.	37	s.	1	4	7	30	7.5	2.8	0.1				
Tacoma	194	172	201	29.86	30.07	+06	37.4	-3.2	57	1	42	17	31	32	18			2.42	-4.4	18	7,054	e.	45	n.	9	3	8	20	8.1	1.5	0.0					
Tatoosh Island	86	9	53	29.94	30.04	+08	40.6	-3.3	51	3																										

TABLE 2.—Data furnished by the Canadian Meteorological Service, December, 1927

Stations	Altitude above sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. +2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	Inches	Inches	Inches	°F.	°F.	°F.	°F.	°F.	°F.	Inches	Inches	Inches
Cape Race, N. F.	99				28.9		36.6	21.3	50	7	2.17		2.9
Sydney, C. B. I.	48												
Halifax, N. S.	88												
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38												
Chatham, N. B.	28												
Father Point, Que.	20												
Quebec, Que.	296	29.66	30.00	-.01	20.9	+5.7	27.4	14.4	43	-4	5.09	+1.40	36.8
Doucet, Que.	1,236												
Montreal, Que.	187	29.78	30.00	-.03	20.0	+4.7	29.4	16.7	48	-1	5.81	+2.16	34.4
Ottawa, Ont.	236	29.75	30.03	+.01	22.3	+5.3	29.2	15.4	44	-4	3.34	+0.43	17.1
Kingston, Ont.	285	29.71	30.03	-.01	27.1	+3.4	33.2	21.1	52	-6	3.33	+0.09	6.4
Toronto, Ont.	379	29.61	30.04	-.01	20.2	+2.2	35.0	23.4	54	8	3.14	+0.23	4.6
Cochrane, Ont.	930												
White River, Ont.	1,244	28.57	29.96	-.01	3.3	-6.4	15.1	-8.4	35	-46	2.27	+0.56	22.7
London, Ont.	808				26.7		32.1	21.4	53	4	4.83		10.0
Southampton, Ont.	656	29.27	30.00	-.02	26.0	-0.7	32.4	19.7	50	-4	6.70	+2.72	49.2
Parry Sound, Ont.	688	29.27	30.00	-.01	22.7	+1.5	29.6	15.8	47	-6	5.80	+1.02	42.0
Port Arthur, Ont.	644	29.32	30.06	+.07	8.6	-4.6	16.7	0.4	38	-20	0.94	+0.07	9.4
Winnipeg, Man.	760												
Minneapolis, Man.	1,690	28.24	30.20	+.18	-7.1	-12.6	2.2	-16.3	51	-33	0.17	-0.45	1.7
Le Pas, Man.	860				-9.5		-2.0	-17.0	22	-31	0.80		8.0
Qu'Appelle, Sask.	2,115	27.78	30.15	+.15	-5.5	-12.9	1.6	-12.6	35	-32	0.30	-0.22	2.8
Moose Jaw, Sask.	1,759				-2.9		4.7	-10.6	38	-28	0.37		3.2
Swift Current, Sask.	2,392	27.44	30.14	+.15	-0.9	-16.9	8.3	-10.0	40	-34	0.66	-0.12	6.4
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.53	30.23	+.22	-8.2	-11.0	1.4	-17.8	33	-36	0.52	-0.22	5.2
Battleford, Sask.	1,592	28.33	30.21	+.22	-7.6	-13.0	0.2	-15.3	40	-34	0.14	-0.18	1.3
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.82	30.08	+.11	36.9	-4.3	40.6	33.3	54	16	3.11	-4.57	5.1
Barkerville, B. C.	4,180												
Estevan Point, B. C.	20												
Prince Rupert, B. C.	170												
Hamilton, Ber.	161	29.94	30.11	-.01	64.8	+0.1	71.0	58.7	79	49	4.36	-0.13	0.0

## LATE REPORTS FOR NOVEMBER, 1927

Sydney, C. B. I.	48	30.05	30.10	+.15	41.8	+4.7	47.6	36.0	62	22	4.08	-1.36	5.0
Halifax, N. S.	88	29.85	29.96	-.05	41.8	+4.5	48.6	34.9	64	21	3.53	-2.13	1.9
Yarmouth, N. S.	65	29.94	30.01	-.01	44.0	+4.1	50.2	37.9	66	25	5.03	+0.54	4.1
Charlottetown, P. E. I.	38	29.97	30.01	+.05	41.0	+5.5	47.0	35.0	63	23	5.74	+1.77	1.0
Chatham, N. B.	28	29.94	29.97	.00	35.7	+4.7	43.1	28.3	67	14	2.62	-1.13	1.5
Medicine Hat, Alb.	2,144	27.64	29.99	-.01	19.7	-7.7	28.2	11.2	59	-10	1.26	+0.34	12.6
Calgary, Alb.	3,428	26.32	30.06	+.08	14.3	-11.5	22.4	6.3	54	-12	1.84	+0.96	18.4
Banff, Alb.	4,521	25.22	29.99	+.03	16.0	-9.8	23.7	8.4	42	-9	2.23	-0.04	20.8
Edmonton, Alb.	2,150	27.63	30.04	+.07	9.6	-13.3	17.9	1.4	51	-30	1.56	+0.98	15.6
Kamloops, B. C.	1,262	28.70	30.03	+.07	28.7	-4.7	34.0	23.4	47	2	2.07	+0.61	27.0
Barkerville, B. C.	4,180	28.47	29.90	.00	16.3	-7.3	23.0	9.6	37	-12	6.75	+3.46	67.5
Estevan Point, B. C.	20				43.4		49.4	37.5	56	31	12.20		0.0
Prince Rupert, B. C.	170				34.9		40.2	29.6	54	21	7.12		19.0

Chart I. Tracks of Centers of Anticyclones, December, 1927. (Inset) Departure of Monthly Mean Pressure from Normal  
(Plotted by A. J. Haidle)

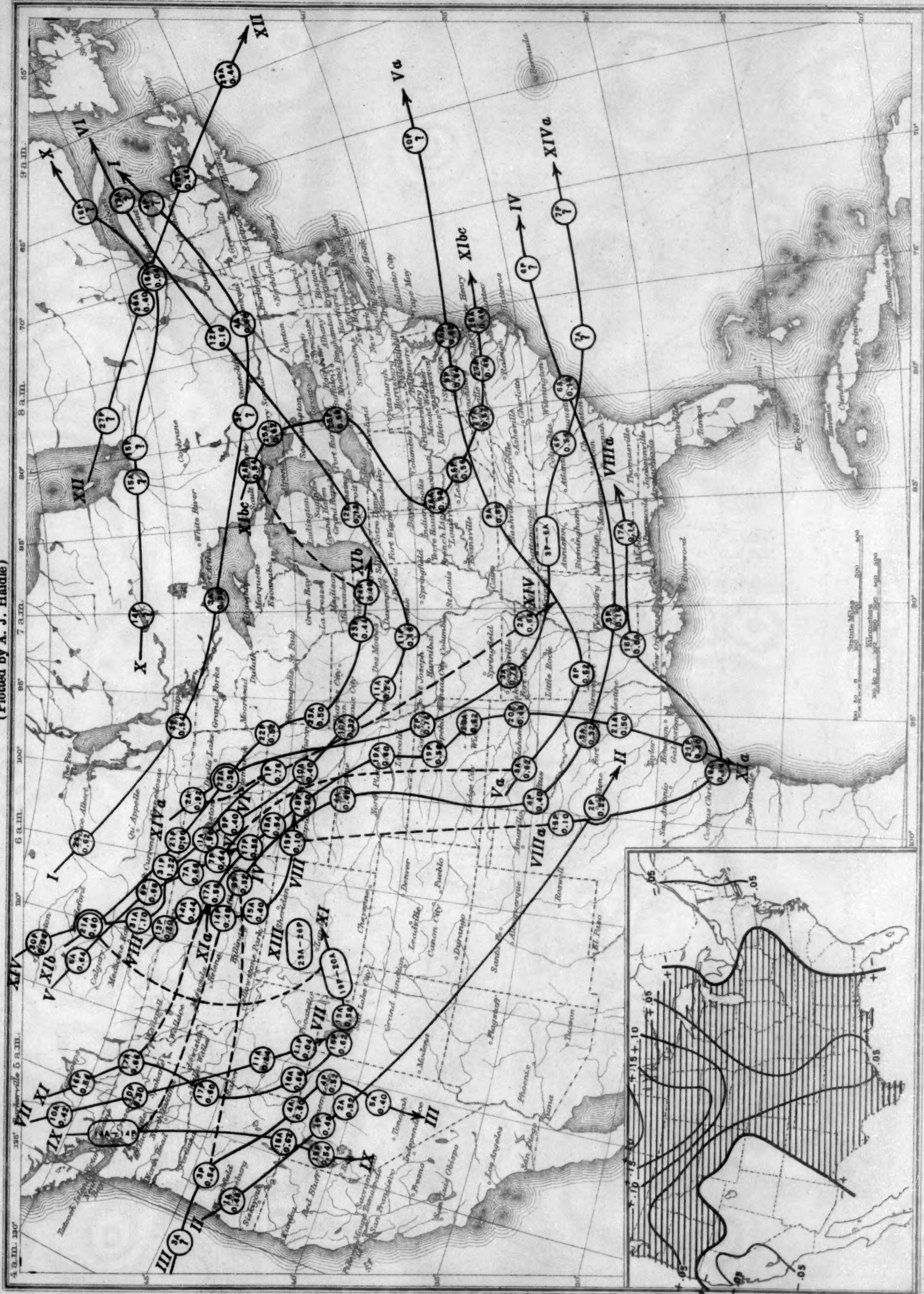


Chart II. Tracks of Centers of Cyclones, December, 1927. (Inset) Change in Mean Pressure from Preceding Month  
(Plotted by A. J. Haidle)

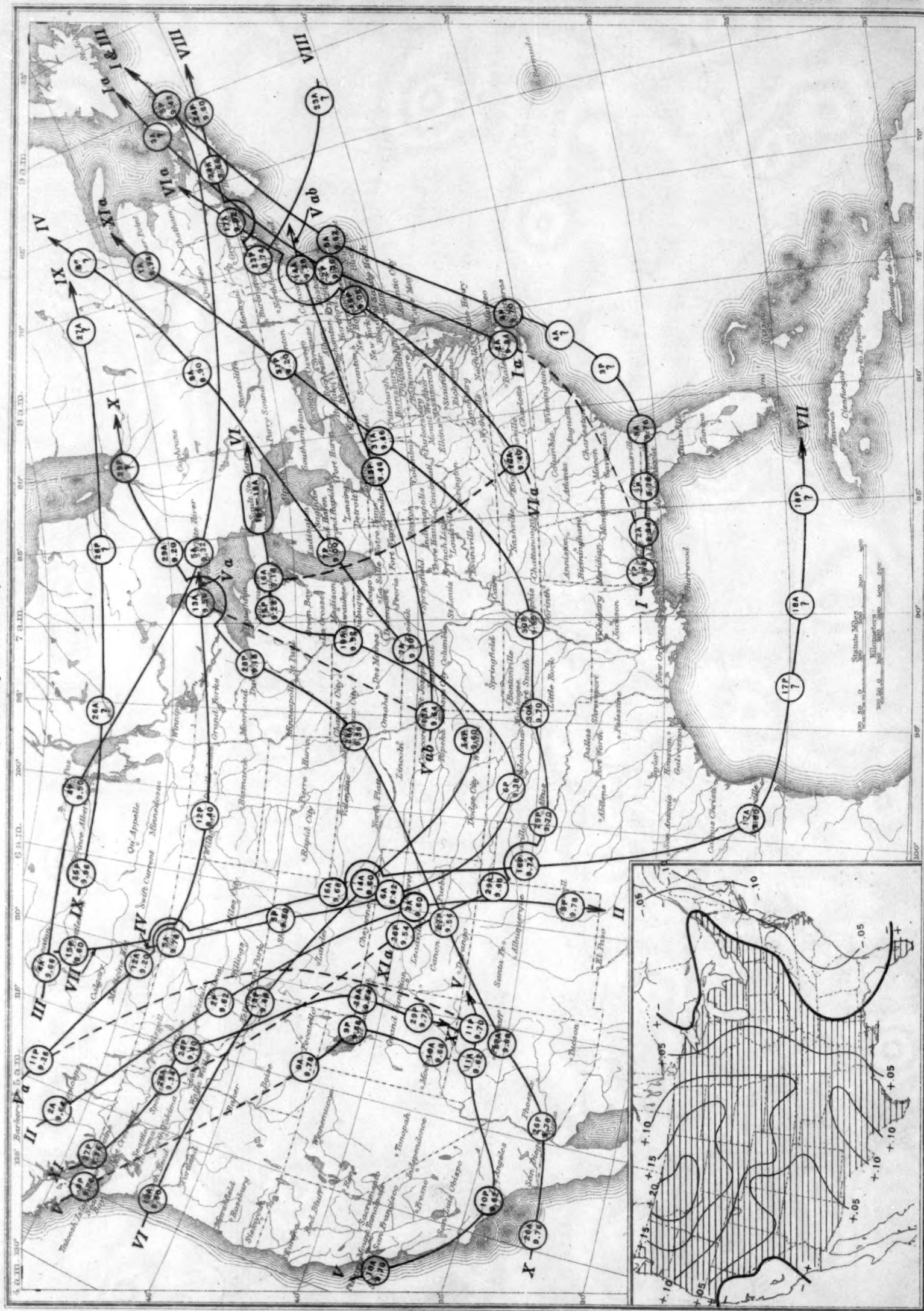
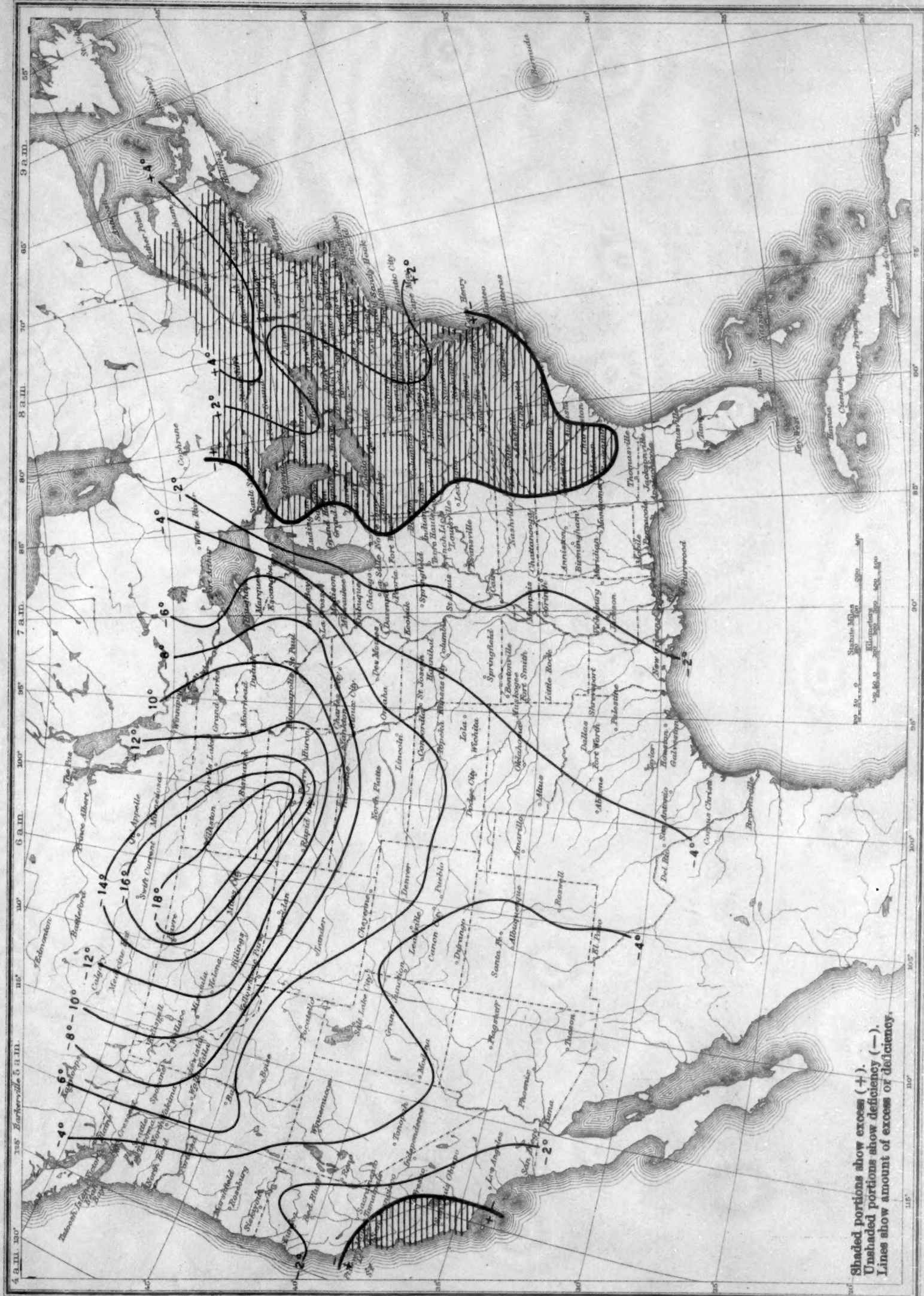


Chart III. Departure (°F.) of the Mean Temperature from the Normal, December, 1927

Chart III. Departure (°F.) of the Mean Temperature from the Normal, December, 1927



Shaded portions show excess (+).  
Unshaded portions show deficiency (-).  
Lines show amount of excess or deficiency.



Chart IV. Total Precipitation, Inches, December, 1927. (Inset) Departure of Precipitation from Normal

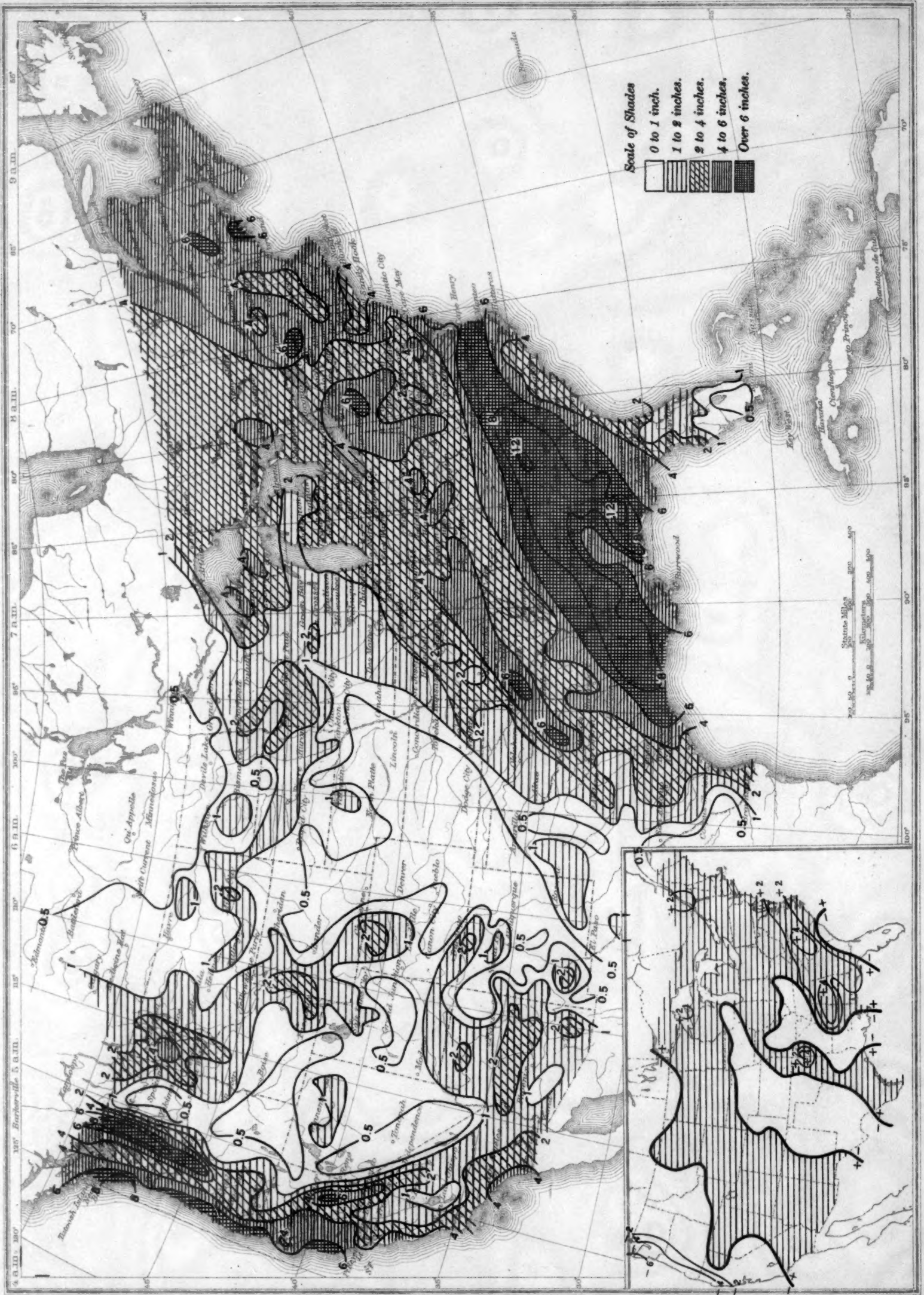


Chart V. Percentage of Clear Sky between Sunrise and Sunset, December, 1927



**Chart V. Percentage of Clear Sky between Sunrise and Sunset, December, 1927**





Chart VII. Total Snowfall, Inches, December, 1927. (Inset) Depth of Snow on Ground at end of Month

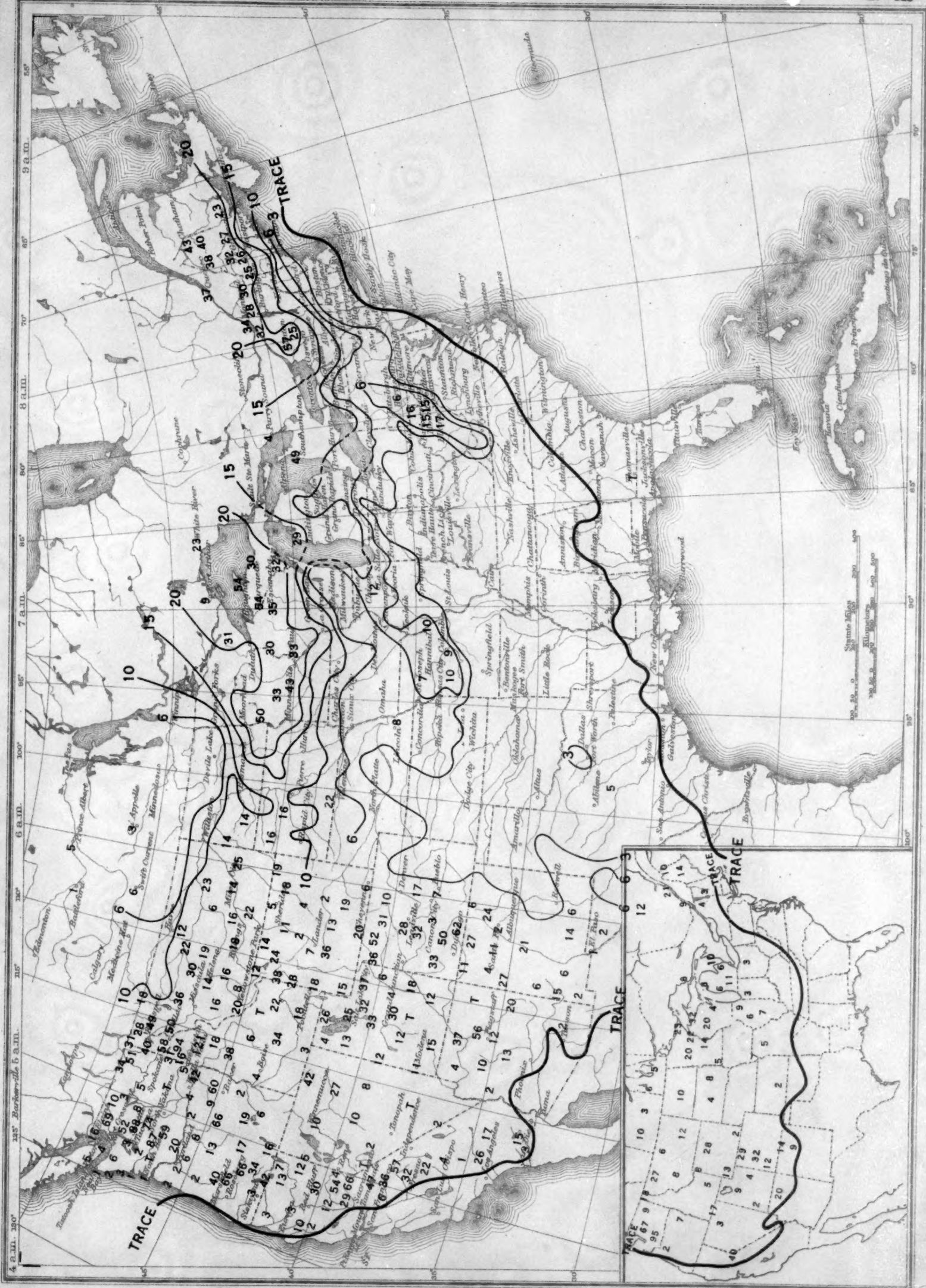


Chart VIII. Weather Map of North Atlantic Ocean, December 15, 1927  
(Plotted by F. A. Young)

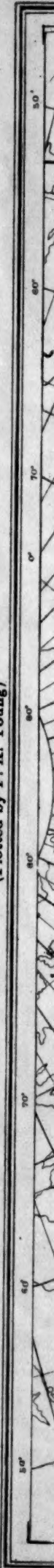
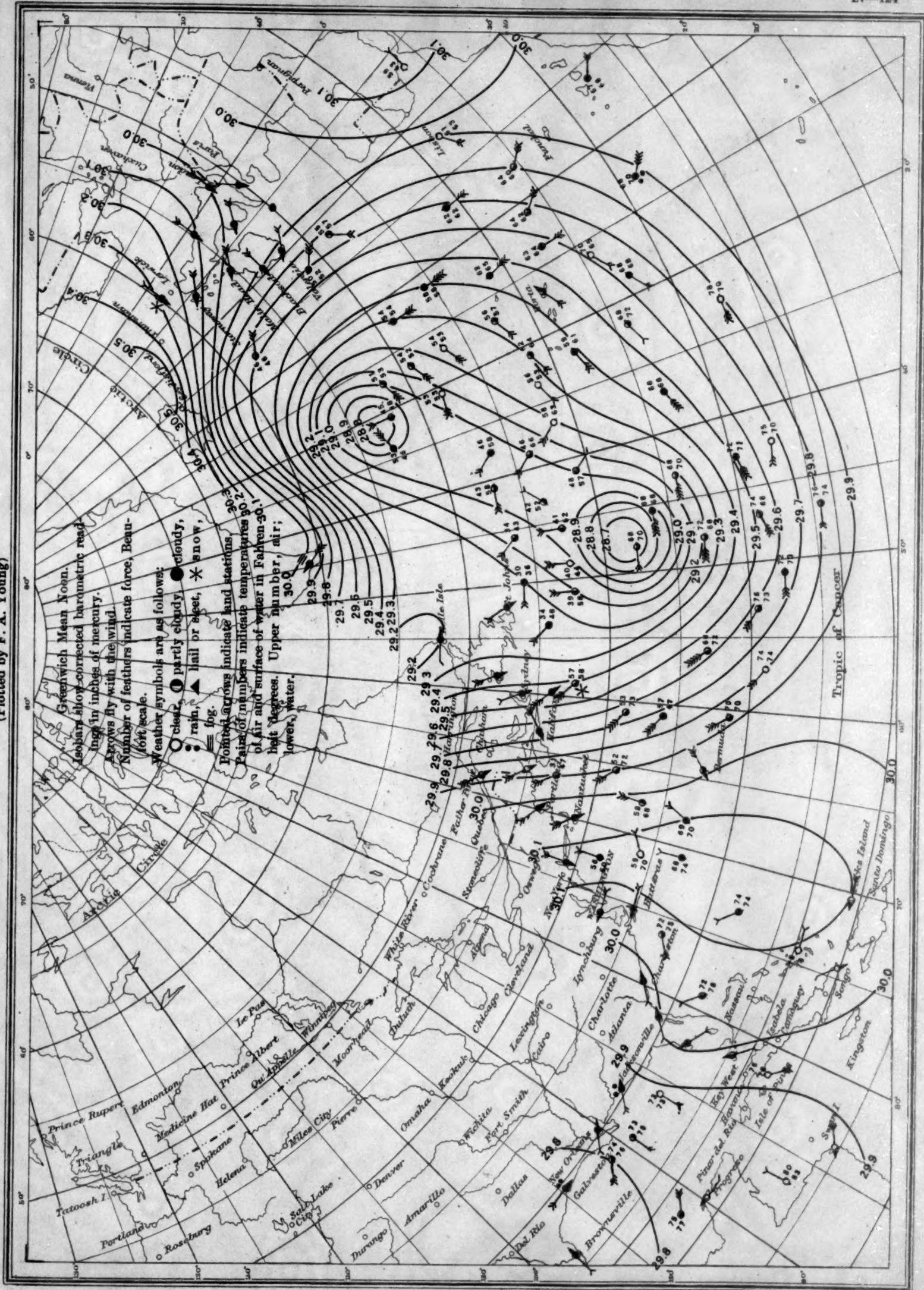
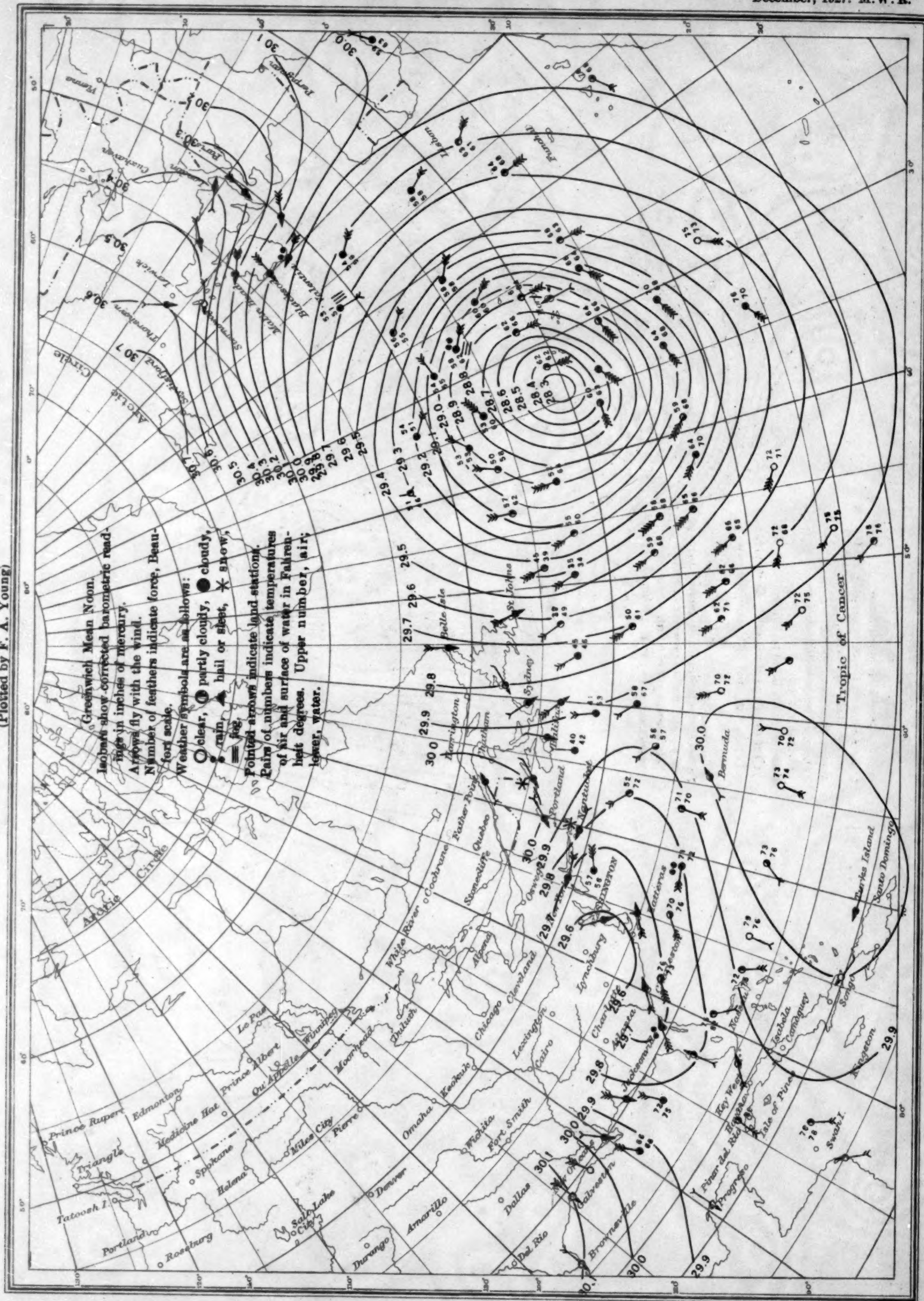


Chart VIII. Weather Map of North Atlantic Ocean, December 16, 1927  
(Plotted by F. A. Young)



(Plotted by F. A. Young)



(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, December 17, 1927

(Plotted by F. A. Young)

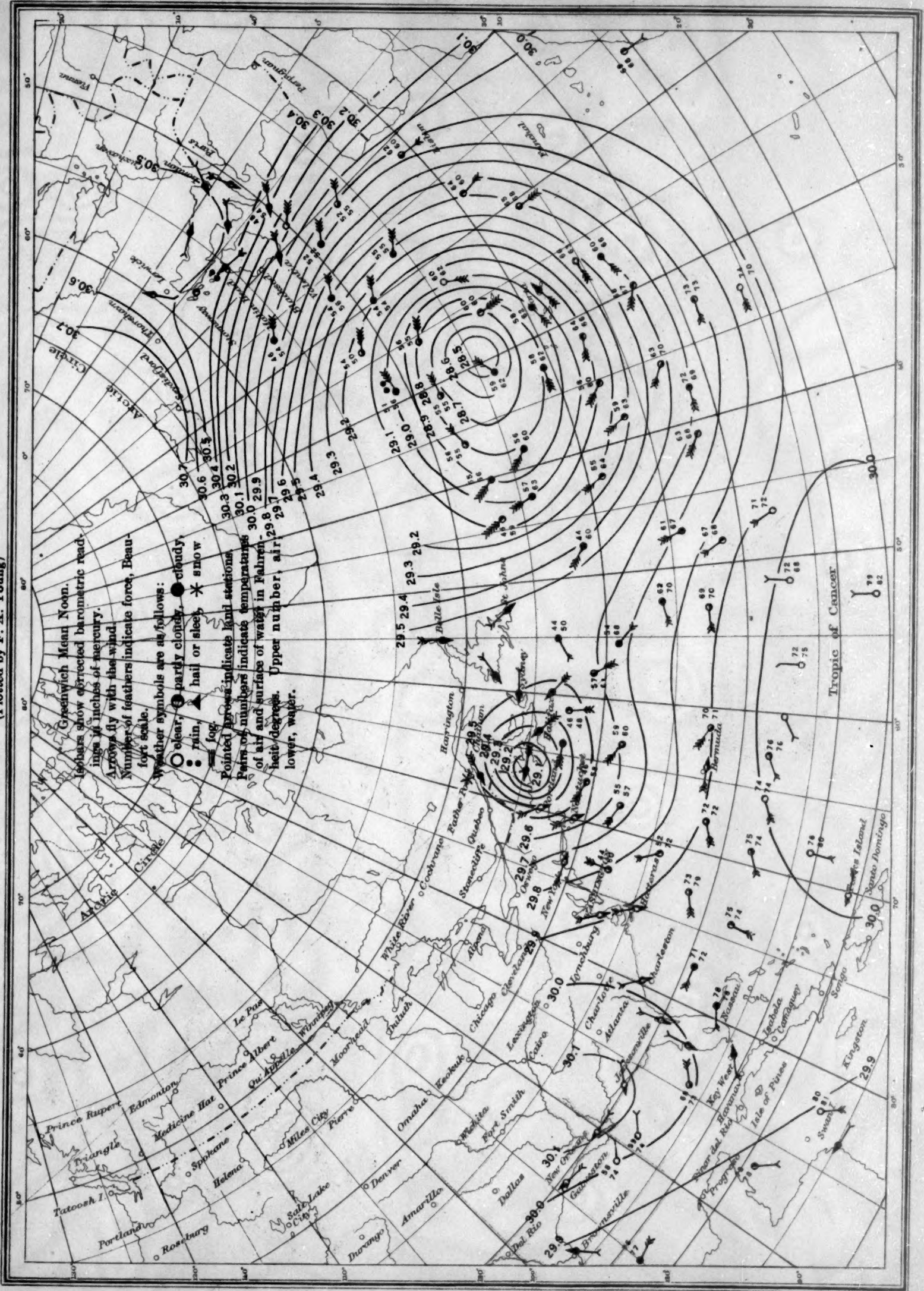
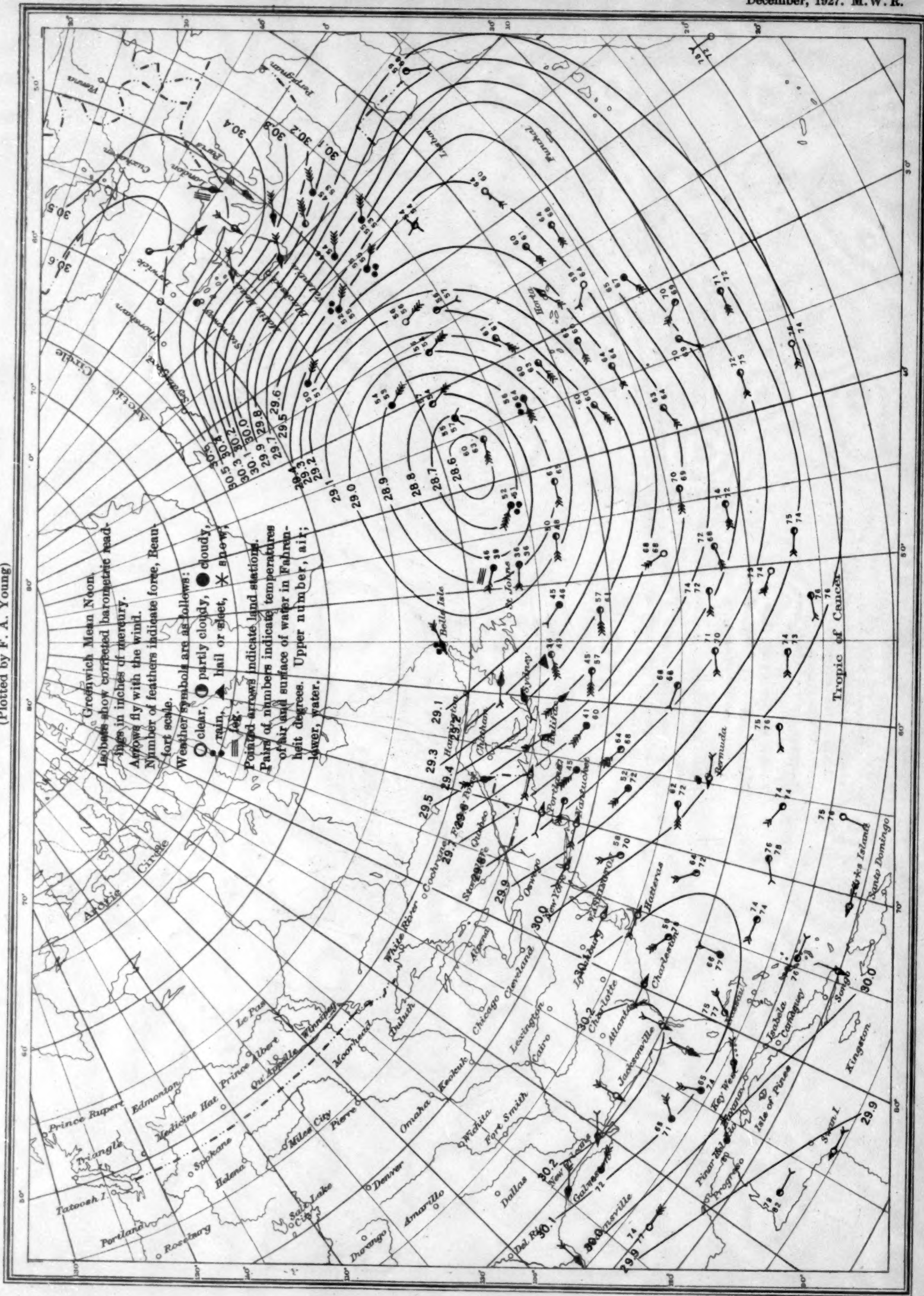


Chart XI. Weather Map of North Atlantic Ocean, December 18, 1927

(Plotted by F. A. Young)





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